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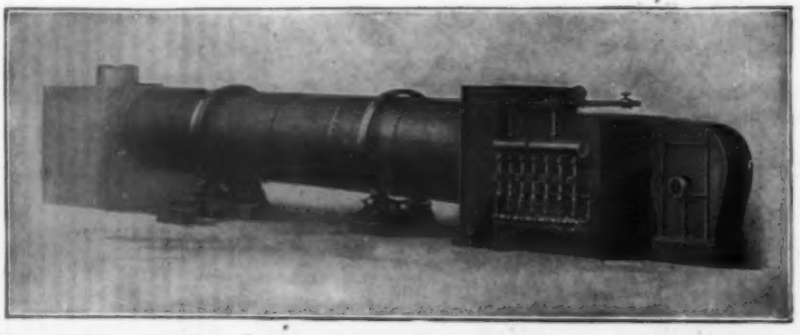

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Pan American Engineering Literature

LA INGENIERIA INTERNACIONAL, the tenth member of our family of engineering magazines, will soon be issued in the Spanish language under the combined efforts of the McGraw-Hill editorial and engineering staffs. We of the chemical and metallurgical realm have especially wished to meet, understand and have greater communication with our neighbors to the South. While it is a fact that CHEM. & MET. has many readers at present in South and Central America, the Philippines and Spain, nevertheless the only efficient way of immediately realizing the much talked of Pan American Union in the engineering field is to break all fetters of speech and print in the most convenient language for our readers. For four and a quarter centuries, Spanish navigators have planted their language in many large but dispersed parts of the world. The general demand for a high class united engineering periodical adapted to these rapidly developing countries has not been met. It is believed that the efforts of the thousand specialists in engineering and publication work now united in the McGraw-Hill Company will be of service to these great peoples.

The Gold Producer and Political Economist

WE HAVE sometimes speculated, as we have perused the technical journals of the year just past, as to how their contents will impress the historian who, fifty years hence, may be inquiring into the state of the art of the metallurgy of gold during 1918. We wonder whether he will conclude that the metallurgists of this day were all political economists or whether all our political economists were metallurgists. Perhaps his verdict may simply be that the pressure of war conditions had gone to our heads.

The gold industry has not been on a normal basis for some years. There is no doubt that it has been seriously ill during the past year, and that the illness is continuing. But if a patient's chance of recovery is determined by the number of physicians in attendance, we may predict a speedy cure. Everywhere the situation has been discussed by congresses, conventions, mass-meetings; the technical press has overflowed with articles on the subject, written by mine-owners, mine-managers, metallurgists, geologists—even editors; the remedy was to be found in bonuses, subsidies, tax-exemptions either direct or indirect. It has all been interesting—certainly; instructive—perhaps. But it has added nothing to the metallurgical achievements of the year.

Unquestionably the metallurgical development of first importance has been Crowe's process of precipitation

in vacuo. A process of pleasing simplicity—and simplicity has characterized most of the valuable inventions—it takes a step which, though clearly indicated years ago by the trend of minor improvements, nevertheless escaped the attention of other metallurgists. The elimination of oxygen from the solutions at the approximate moment of precipitation is readily accomplished. The necessary apparatus is inexpensive and the power consumption almost negligible. The resulting saving of precipitant may be, we are informed, as much as 30 per cent.

But the various steps in the cyanide process are so inter-related that the possibilities resulting from the application of this process do not stop here. Thus, as the reduced amount of precipitant naturally leads to improvement in the grade of precipitate, we may speculate as to the probable evolution of refining methods. As we suggested a year ago, the electric furnace may appear in regular practice as a result of these changed conditions; on the other hand, the possible revivification of refining by distillation and recovery of the zinc from the precipitate seems more remote.

Again, although the process benefits in a measure both zinc-dust and zinc-shaving precipitation, its effect will be to improve the relative position of the former in popular favor. Ten years ago the dust method failed of establishment in South Africa, primarily because it could not, in the then state of the art, compete with shavings in the precipitation of a very dilute solution. It seems possible that, reinforced by the Crowe process, a different verdict will be given if the case is reopened.

This, too, is rendered more likely by the continuing development of American zinc-dusts of superior quality. Several such dusts, regularly marketed to-day, are consistently better than the best Silesian dust of 1914 and earlier. Here is one permanent gain for American industry.

Almost simultaneous with the advance in zinc-dust precipitation in America has been a successful development of charcoal precipitation by EDMANDS and MOORE, at the Yuanmi plant in Australia. The precipitating action of various forms of carbon has been for many years a subject of discussion, and we believe it to be the generally accepted conclusion that the actual work of precipitation is done, not by the carbon directly, but by adsorbed gases. This view is supported by the fact that graphite is without action. The very recent campaign for peach-pits and similar shells of vegetable origin, to be converted into charcoal for use in gas-masks, is an interesting illustration of the variation of this property in different charcoals. In the discussion of EDMANDS' paper before the Institution of Mining and Metallurgy, this question was touched upon, and it was emphasized that the successful work at the Yuanmi might have been due, in a measure at least, to the use of charcoal made from mulga—an Australian hardwood.

The precipitating action of certain carbonaceous rocks has often been a source of difficulty in cyaniding, preventing satisfactory extractions through the premature precipitation of some dissolved gold. Work by FELDTMANN and WARTENWEILER on West African ores has shown that such gold may be redissolved in sodium sulphide solutions, and an ingenious process has applied this principle. It seems to have possibilities in other localities.

The special applications of cyaniding to silver ores have experienced no additions during the year, but the work being done in Colorado, under the direction of the Bureau of Mines, will be awaited with interest. This investigation looks to the beneficiation of the manganese-silver ores, so frequent in occurrence and so generally refractory, and we understand that it offers excellent promise.

Flotation, as affecting gold and silver metallurgy, remains as it was a year ago. Mechanically, too, the year has little to record. Practically no new construction has been coming forward, and no new light has been thrown on the crushing problem. BLOMFIELD published an able paper in discussion of Golden Cycle milling, and the data given of the performance of the bowl classifier—the latest of the Dorr machines—suggest that it will have a considerable field of usefulness.

The cyanider is interested in the future of the great nitrogen-fixation plants proposed for war purposes. He is looking to these, and perhaps also to the more serious efforts to produce cyanide from cynanamide, for a considerable reduction in the price of cyanide and for a little healthy competition in the business.

An Engineering Opportunity—The By-Product Coke Oven

THE chance to note the possible improvements in chemical engineering were never greater than at present. Of course, most of us think first of the opportunities naturally furnished or suggested by the sudden change from war to peace—military peace—though it is possible that commercial war of natural competition will be more strenuous than ever.

Among the matters of first importance are the ever vital questions of power and fuel; for, as FRANCIS BACON observed, with his marvelous insight, "As the soul is the former of forms and as the hand is the instrument of instruments, so fire is the helper of helps." PROMETHEUS was well called the friend of man, when he is feigned as bringing down fire from heaven to give to humanity; and well might JOVE himself be jealous of this incomparable gift to his creatures. But it is surprising that we of the twentieth century should be so backward in using and applying this "helper of helps" with so little efficiency and economy.

Among the great developments of the age there may be well counted the "by-product coke" industry. There are several makers of plants that are gradually but surely replacing the old emergency "beehive ovens," which in all candor were devised solely for the purpose of making coke. The iron and steel industry must have coke, and the beehive furnished it; and to the beehive must be given the credit of building up the iron and steel business.

But with the advent of the varied savings of the by-product oven the question still comes up: Why do not the designing engineers go further and study the actual conditions of the by-product process, with its marvelous production and with its marvelous waste? Let us look at it broadly.

It is now a fact, practically recognized by most of the leading gas engineers, that the carbonizing of coal to coke is a process in itself, which, when the coking temperature once is reached and maintained, ought to go on of itself, as though it were almost neutral in its

heat absorption or possibly actually exothermic. This means that, when the coking temperature is once reached, the process ought to go on with the expenditure of no more heat; it ought to be practically automatic. But what do we actually see?

The facts are that the ordinary by-product oven is a gas machine that uses half of the gas produced to maintain the process; that the huge mass of ovens and retorts, with their heating chambers and regenerators or recuperators, is one big, wasteful heat-radiator—and a very wasteful radiator. One cannot step close to the oven pile with any comfort. It is simply one big heat sieve, throwing off good energy—up the stack, and out at the sides, and in all directions. Moreover, the time element is something that is but poorly camouflaged under the enormous profit-and-loss account that seems to carry the whole scheme—the time lost is something that the twentieth century engineer would shudder at if it were put up to him for a first consideration; and we are forced to the conclusion of the farmer who settled all questions of farm economy by saying, "What's the use of time to a hog?"

This wasteful heat-hog of the by-product oven must have come from some such origin as the Hunnish character of some of the names suggest. No Yankee would ever have dared to try to put any such thing across. Only a so-called civilization that was reckless of the time element would ever have had the gall to plan for a carbonization process that takes the best part of a day to coke one oven; and the trick of merely multiplying this by "*x*" or "*n*"—this does not excuse the monumental blunder of the first design, nor its subsequent foisting off on the American public. The only wonder of it all is that it ever happened. It looks as though some of us ought not to be allowed to run around loose without a guardian to watch us and to see that we did not take up with the first "gold brick" that was offered us.

And let us see wherein this wasteful process is wasteful. Here let us notice that the by-product process in general is one of marvelous perfection of well planned detail, so marvelous in its exactly calculated wealth of detail that it is itself a wonder of invention. This well planned process is apparently carefully designed; but it is designed on the wrong plan. It reminds us of the wonderful design that Mother Nature showed when she spent so much time and effort on making the insect creation—a creation that came near rivaling the mental and physical powers of man, but it was designed on the wrong anatomical plan. So of the by-product plan; it is wrong in one—one at least—small feature; that is the heating wall of the oven where the carbonization is done. This heating wall is composed of bricks or the equivalent, which will convey the heat through the wall —in time, that is, the best part of a day.

Think of it! Trying to force the heat necessary to carbonize the coal to coke—and it cannot be great—through some six or eight inches of earthy material. For, to illustrate the case of one of the better grade of ovens, the walls are composed of silica brick six or eight inches long; and the heat must travel endwise through the entire length of the brick to reach the coal. It is no wonder that this heat-conduction process must take nearly a day. It is here that the inventor has a chance to improve on the silica-brick heat-conductor.

To be sure, it is well known that the heat-conductivity of the silica brick is considerably greater than the conductivity of the fire-clay brick that were used for the oven walls earlier; but that does not evade the main question of the time loss of the general process. Neither does the contention of some of the engineers answer the time-loss matter; in that the heat-conductivity of the coal and coke in the inside of the oven is stated to be so slow that the slow heat-conduction of the silica-brick walls can keep up with it.

The facts of the heat-conductivity of the coal or coke in the inside of the oven are not well worked up; but the best authority on the subject tells us that there is no doubt that the heat-conductivity of the coal or coke is immensely greater than the heat-conductivity of the silica-brick walls; though one must consider the heat-insulating power of the porosity of the coal or coke, this latter element causing the heat-conductivity to be retarded about in direct ratio to the porosity. But even then it is fair to assume that the practical heat-conductivity of the average coal or coke must be immensely greater than what it utilized.

There is a strong suspicion that the attempt of some of the gas engineers to cover up this point indicates that they are gradually becoming aware that there is something fundamentally wrong with the design of the by-product coke oven. Moreover, the very necessity of driving the heat-conduction of the silica walls of the oven is so strenuous that the whole process is conducted at temperatures much greater than are necessary for the carbonization of coal to coke. To be sure, the quality of the coke produced—and it must be noted that the purpose of the by-product coke oven is in the first place, generally, the making of coke—is said to be better and more uniform than that of the usual beehive oven; but this is the natural result perhaps of the great care and attention that have been given to this phase of the process. It does not follow that it is impossible to make good coke at lower temperatures or in shorter time.

But the main thing to note is that it ought to be possible to find some material of better, much better, heat-conducting power for the oven wall, that shall replace the silica brick, with its sluggish time factor. Some of us think that we have found some such substitute. The matter is being aimed at, and in due time will be developed; but the wonder is that this marvelous opportunity should not have been studied long ago. The wonder is that such a peculiar case of wrong invention as the silica brick, for this purpose, should ever have had its day. To be sure, it is just like the history of invention that such experiences should happen; but once the matter is brought out into the light it ought to be a plain case of improving it.

Of course, the secret files of many of the large companies might be able to disclose many interesting facts; and we may, in time, find out why this case has been allowed to lie dormant. It is suggestive and will prove interesting matter for the later historian of chemical and metallurgical progress. It may well be that the apparent facts of the case are opposed to any revolutionary changes; it may well be that some fool inventor may find the solution, just because he did not happen to know that the desired improvement is impossible, and so simply may go ahead and find what we are looking for. But whatever the issue of the case, the general

question is worth while studying; for it is patent that we must soon find a more economical method of making gas in such quantities as has not yet been dreamed of. For instance, it ought to be possible to plan for the day when no solid fuel shall be carried into such a congested place as Manhattan Island, for instance; but when all the fuel shall be piped over as gas, or, better, as electricity. It ought to be possible for the time to come when no coal shall be carried from the mine, but when it shall be turned into gas (or electricity) directly at the mine mouth. Such dreams are only the precursor of the reality; for, other things being equal, whatever is rationally thinkable, that is mechanically possible.

Meanwhile, of course, there are possible ways of saving much of the heat now wasted, from the constant radiation in all directions, from such heated masses as by-product ovens, glass pots and the like. It ought to be possible to recover much of this waste by a simple regenerator jacket about the mass, or about its most exposed parts; but the main suggestion is worth pondering; it will arrive in due time, with full realization.

The Metallurgy of Copper in 1918

COPPER production in the United States, steadily climbing from the minimum established at the outbreak of the war, reached a peak in the summer months of 1917. Totals for 1918 will exceed those of 1917 only beacuse operations were paralyzed during the second half of the previous year on account of an epidemic of labor troubles. As to labor, many scattered incipient outbreaks fortunately were speedily adjusted, and so the year 1918 has been one of apparent quietude and unprecedented wage scales. The steadily decreasing volume and efficiency of labor have made it increasingly difficult to supply the war orders even at the good prices current. Naturally there were instituted but few notable additions to smelting plant—it was difficult enough to keep the old capacity satisfied. This combination of circumstances has forced many mines to retrench on exploratory work and skim the cream of their deposits, leading to a "worked-out" condition which may prove disastrous in a falling market, and certainly will require the most expert technical knowledge to bridge. It is yet too soon to appraise the effect which the return to peace will have upon the price and requirements of the metal and of the commodities and labor needed for its production. The utter absence of demand for copper may reflect a widespread opinion among the consumers that the prices of copper, as well as of other things, are war-inflated and due for a drop.

More than ever it was incumbent upon the mill superintendent to recover all the copper possible from the ore sent to him. The use of flotation, either as a substitute or adjunct to gravity concentration, had already been successfully established and had greatly improved the recovery on properly sized sulphides. How to concentrate the unfloatable copper oxides, carbonates and silicates in the tailings has received much study during the year, and several large mills have attacked their individual problems successfully. Hydrogen sulphide, alkaline sulphides and sulphur dioxide are favorite reagents added to sulphidize a sufficient area of the oxide particle so that it may float. Less soluble silicates, partially oxidized ores and tailing piles may perhaps better be first leached with sulphuric acid, when the cleaned sulphides remaining float very cleanly. Enormous and increasing quantities of copper are being recovered by such schemes at the Hurley, Hayden, Miami, Garfield and Anaconda, and have been responsible for corresponding increases in output of by-product sulphuric acid.

Adequate roasting is the kingpin of successful smelting. This has been demonstrated again at Humboldt, where the installation of a modern and ample roaster department increased reverberatory furnace tonnage so largely as to shut down the blast furnaces; the grade of matte was also increased and properly controlled, with a corresponding reduction in converter work and costs. Experiments have shown that sulphur burns out of fine concentrates as they drop from hearth to hearth at a much higher rate than while being rabbled. Since we are now able to cope with the dust problem, roaster evolution may well be toward high shafts with many narrow hearths, so that the ore will spend a larger part of its time surrounded by heated air. It has also been recognized that the fuel ratio in reverberatory smelting depends directly upon the temperature of the calcine charged. Therefore, efforts have been made to reduce avoidable radiation losses by insulating the hoppers and making a quick transfer.

Metallurgists at Douglas have made much admirable progress in their reverberatory practice. STOUT, at the Copper Queen, doubled the size of the uptakes in order to avoid choking the draft at the skimming end of the furnace, and found that he was able to burn a largely increased quantity of fuel, with even greater efficiency. COLE and JACKS at the Calumet and Arizona, following in his footsteps, found that the excessive heat at the uptake melted down the furnace arch very quickly. In trying to avoid the large losses in time and money caused by such failures, they controlled and shortened the fire zone by proper air inlets around the burners and through the arch. Almost any step which will increase the concentration of heat appears to be desirable:—a flat verb with large flue areas, larger oil nozzles blowing superheated oil with compressed air, roof ports, double banks of burners, hotter calcine. For best results, then, an explosive flame burning fuel at the maximum rate should fill the fire-end of the furnace only as far as the last charge-hole. STOUT even advocates drawing off the gases at the middle of the furnace, converting the skimming bay into a large settler, independently heated and charged with sufficient pyritic material to wash the slags very thoroughly and thereby reduce their copper content.

By properly adjusting the length of flame and increasing its combustion rate, these Arizona plants have achieved remarkable furnace capacities and fuel ratios. Thus, the best daily average for the 19 by 100-ft. reverberatories at the Calumet and Arizona was 400 tons of calcine at a fuel ratio of 0.75 barrel oil per ton. Since revising the burning-practice these figures have increased to 800 tons at 0.62 barrel. The huge 38 by 130-ft. furnace at El Paso has done even better with 850 tons at 0.61 barrel, and has attained a remarkable daily maximum of 964 tons. The best fuel-ratio will occur when charging calcine at the maximum heat—

Capt. STOUT has set his ambition at 0.45 barrel of oil per ton of calcine charged at 1150 deg. F.

Excellent furnace practice is not confined to these oil-burning reverberatories. Thus at Garfield, by careful adjustment of combustion and charging practice, it has been possible to smelt regularly 600 tons of calcine daily with but 15 per cent of powdered fuel, while a larger furnace at Anaconda cleans 500 tons of converter slag by melting an equal quantity of partially roasted concentrates with a fuel expenditure of 8 per cent.

The question "Oil versus Powdered Coal" is of course largely decided by relative costs; it is significant, however, that plants so far from coal fields as Hayden, Clarkedale and Tacoma have recently installed powdered-coal systems.

Basic-lined converters of extraordinary size have proved their superiority wherever a sufficient quantity of matte is available to keep them in blast. Operating on 16 per cent matte, as at Anyox, they exemplify the principles of pure pyritic smelting. The use of the silica gun has more than fulfilled expectations, uniform operations and temperatures have lengthened the interval between lining repairs and allow the production of a slag higher in silica. In case converter slag is hot-charged into reverberatory furnaces, it is then more nearly of the same specific gravity and will diffuse somewhat more readily into the reverberatory slag. This may be of considerable advantage in the economical recovery of its copper content.

Adequate flue and chimney capacity is evidently essential for the best developments in reverberatory smelting. The number of Cottrell plants and high stacks recently under construction (notably El Paso, Hayden, Humboldt, Anaconda and Tacoma) indicates that many metallurgists agree with O'GARA'S ideas on smoke dissipation. One is justified in spending money only for the recovery of the actual values in the gas; the remaining more or less dangerous constituents can best be eliminated by means of stacks discharging smoke at proper temperature and proper elevation so that it will be reduced to an innocuous dilution before reaching the ground.

Iron and Steel in Last Year of War

THE salient feature of war time control of the iron and steel industry was this, that before all the direct war needs and the requirements of the "essential" commercial industries were provided for there was no steel left. Another feature was that when complete lists of all the industrial activities that were adjudged helpful toward winning the war were drawn up there were very few industries that consume steel that were left out. Two things were proved, first, that in waging modern warfare nearly all industries are needful, and second, that steel is the backbone of nearly all industries. No defined industry of any importance was omitted in the distribution of steel, but certain "purposes" were recognized, leaving other purposes unrecognized. The manufacture of passenger automobiles for public sale was not recognized, but the automobile shops were given orders for passenger vehicles and trucks for war use. Building for civilian purposes was not recognized, but there was much building for war purposes.

The condition that resulted from active participation in the war was one that was not dreamed of even by the most far-seeing when the country declared war. Then the trade engaged in speculation as to what part of the steel output would be required for war purposes, and estimates that placed the proportion at one-third were among the highest. The steel trade, usually gifted with keen vision, thought of steel demand in war time as made up of shell steel, gun steel and similar items. From such a viewpoint, all our steel could not possibly be needed, for in terms of ingots our capacity was nearly 45,000,000 tons, while the Central Powers commanded only a trifle more than 22,000,000 tons, and the Entente Allies, with the aid of steel imported from the United States, had hardly commanded as much more. Thus, apparently, only a small part of our steel would be required to upset the balance. The error lay in failing to recognize that everything possible was to be marshaled. Public service corporations would be expected to render the fullest possible service, and thus would need steel, and so with railroads, machine shops, agricultural implement factories and very nearly all the mines of every description. Instead of plowshares being beaten into swords, more plowshares were wanted.

What did the steel industry do? The division may not appeal to the purist, but the industry's output of steel may be considered from three viewpoints, of quantity, of character and of quality. As to quantity, the industry produced about 42,000,000 gross tons of ingots in 1918, when its capacity, given favorable conditions in all respects, was fully 47,000,000 tons. As to character, the industry showed a flexibility that had never been recognized in it, for it converted an altogether unexpectedly large percentage of its steel into plates, it turned out enormous quantities of shell steel through rolls that had never been thought of in connection with such sections and it made tin plate at a wonderful rate. As to quality, many mills produced steel shell and other steel of fine quality when previously they had never thought of making anything but the commonest kind of steel. The industry produced wire to tensile strength specifications that at first made the more sanguine stand aghast. It produced seamless and welded tubes of better quality than ever before. It produced and rolled electric steel for helmets that were admitted to be the best on the battlefront.

There is no doubt that the steel industry's capacity in 1918 was fully 47,000,000 tons of ingots, that estimate being based upon actual production in 1916, plus allowances, on a conservative basis, for new construction. About 2,000,000 tons output was lost in January and February through the railroad breakdown, affecting the steel industry chiefly through short supplies of coke. The influenza epidemic curtailed output in October and November, perhaps by half a million tons. There was some relaxation after the armistice, production being slightly less than would have been the case if the war had continued. Throughout the year there was a shortage of labor, and there were various minor difficulties as to the securing of supplies and equipment, that exercised some influence in limiting production. An important factor was the shortage of scrap of good quality, such as conduces to heavy open-hearth furnace tonnages.

The American steel industry, however, emerges from the war with its capacity increased about 40 per cent.

Western Chemical and Metallurgical Field

Ohio Copper Mill

THE Ohio Copper Mill at Lark, Utah, was completed late in 1909, at a cost of about $1,300,000. Erected by Heinze interests, it was one of the three big mills in the Salt Lake region treating disseminated copper ores from Bingham canyon. Unlike the ore from the Utah Copper and Boston Consolidated ground, it handled a hard, very tough quartzite sliming less in crushing than the softer porphyries. Since some rather high-grade ore from the upper levels was to be treated, Hartz jigs were installed to concentrate the coarse material delivered by Blake crushers and intermediate rolls. Jig tailings, together with coarse spigot discharges, were reground in Chilean mills. The bulk of the plant consisted of hundreds of tables; high-silica concentrates made on primary tables were recleaned on secondary tables designed to increase the copper content, while the dewatered slimes were concentrated on more Wilfleys, whose overflow was passed over slime tables before being finally discarded.

This plant was very carefully designed after large-scale tests on the ore, and incorporated the best ideas of the time. Operating on a low-grade ore, the concentration ratio reached a value of 20 to 1. Some 8 million tons of ore were treated before the steadily decreasing ore content caused the abandonment of gravity concentration.

At the present time practically all the original equipment is being removed to make way for a more compact flotation plant. Three 600-ton units are now in operation in the south end of the building, and work is well under way on two additional sections; the total capacity is thus increased while needing less than ½ the total building space. Fortunately, the disastrous fire occurring last August burned only the north end of the ore bins—which is the only portion of the plant containing much wood in the superstructure—and interfered but little with operations of the modernized sections. The destroyed bins are being rapidly replaced with reinforced concrete construction.

As compared to the older flow sheet, the flotation plant is simple and direct. The coarse crushing plant, capable of crushing 3000 tons per day, consists of one primary Blake and three sets of 60 by 24-in. Garfield rolls in closed circuit with 4 duplex whip-tap screens, screening to ¾ in. Until such time as the above arrangement is completed, the ore is being broken to 1½ in. in two Blake crushers before being sent to the fine-ore bins. The ¾-in. product will be washed in a locally-made drag to remove the natural slime in the ore. Primary grinding for each unit is done in the first of two 8-ft. by 36-in. Hardinge mills, which discharges into a Dorr duplex drag classifier. Oversize from the classifier enters the second Hardinge, operating in closed circuit. The overflow from the Dorr classifier goes direct to a 16-cell M. S. flotation machine.

Flotation tailings are at present passed over Wilfley tables to recover coarse sulphides, but due to the high recovery of the flotation machines they will probably be discontinued. A pair of Janney machines are being installed in each unit to clean up the M. S. concentrate. Flotation concentrates from three sections are dewatered in three 42 x 10-ft. Dorr thickeners, whose pulp feeds a pair of 12 x 12-ft. Portland filters. Lowden driers bring the moisture in the filter cake down to 15 per cent.

Original difficulties in maintaining expected extraction have been overcome by A. H. HELLER, mill superintendent, by removing the natural slime occurring in the ore, which exerts an influence on recovery out of all proportion to its absolute quantity. As previously noted, this is effected by washing the fine ore in a locally made drag, capable of handling material up to ¾ in. without difficulty. Careful attention to the relative proportions of coal tar and pine oils is necessary so that no unoiled particles of sulphides appear when panning the tailings. The profitable treatment of such low-grade ore, mined by expensive underground methods during times of high commodity and labor costs, is an achievement of more than ordinary merit.

The Joplin Zinc Situation

AT THE instance of POPE YEATMAN of the War Industries Board, a committee from the Joplin Ore Producers' Association met with a committee representing the zinc mining and smelting industry in its relations with the government during the middle of October, and formulated an agreement effective for three months which was designed to reduce the wide "spread" between the price of metal and ore which has recently caused a sharp curtailment of mining. According to W. B. SHACKELFORD, a member of the conference, the agreement was based on the following figures:

Cost of producing 60 per cent. concentrates, including royalty: $60 per ton.

Cost at gas smelters, not including risk of failure of fuel supply: $23.50 to $26 per ton.

Cost at coal smelters, not deducting return for acid: $32.50 to $34 per ton.

Average cost of smelting, basis: zinc at St. Louis: $30 per ton.

Smelter recovery: 83 per cent.

Thus it was found that if the spelter market were quoted as $8.75 per hundred pounds and the ratio between metal and ore were at 6.52, the mine and smelter would both receive about enough to pay their expenses. Therefore it seemed proper to adjust a sliding scale such that when the spelter market was quoted at $6 per hundred the price of 60 per cent ore would be 6.80 times the price of zinc, or $40.80. The ratio decreases by one hundredth for each tenth of a cent advance in zinc per pound; thus, at a 10-cent market, the ratio is $6.80 - 0.01(10.0 - 6.0) = 6.40$, and the price of ore would be 10×6.40 or $64, subject to the usual premiums and penalties for composition. To stabilize the market the agreement further specified that the smelters would obligate themselves to absorb a certain amount of ore weekly for the period of the agreement.

In order for the plan to become effective it was necessary for practically all the smelters handling Joplin ore to sign the agreement. About 70 per cent of the smelter tonnage signed, and nearly all the mines in the district became a party to the agreement. During the

first week, the signatory smelters purchased 2400 tons at the agreed price of $55.67, while outsiders secured 1300 tons at from $52.50 to $55. During the week ended Nov. 17, however, many buyers remained out of the market, and but 2300 tons were purchased at the agreed price of $54.53, while 1700 tons were picked up at prices ranging down to $45. Unfortunately the agreement contained no stipulation binding the miners to refuse offers at less than the agreed price, and many in financial straits were forced to realize on their concentrates.

Joplin ore producers therefore voted on Nov. 16 to curtail or suspend operations in view of the very large accumulation of unsold concentrates, leaving the situation in the hands of "outlaw" miners and buyers.

Suspension was contingent, however, upon obtaining signatures of 60 per cent of the production, which was not forthcoming. Smelters then agreed to state the weekly amount of ore required, which would then be allocated among the mines. Completion of storage warehouses for 150,000 tons of ore is also expected to stabilize the situation materially, since miners could borrow 90 per cent of value on warehouse receipts. Meantime spelter is dull and weak and the situation is disarranged by sales of a large amount of concentrates at the market by a big company on telegraphic orders from the owner.

Curtailment and shutdowns are now the order of the day for higher cost producers; in fact, the sheet ground region near Duenweg is practically abandoned at present.

Ferromanganese at Great Falls, Mont.

OPERATION of the ferromanganese department at the Great Falls plant of the Anaconda Copper Mining Co. began about the middle of September, when the first of the electric furnaces was started. The proposed plant was briefly described on page 391 of our issue of April 15, 1918, construction having started early in March.

Each of the furnaces consists of an open-topped shallow brick shaft, 28 x 14 x 11 ft. in outside dimensions. The outer walls are of red building brick with an inner firebrick lining. This shaft has a tamped lining composed of dead burned magnesite with pitch as a binder. The tamped lining is 3 ft. thick in the bottom and is brought up the sides to a point about 18 in. above the tap-hole level. The inner dimensions of the shaft at the middle section are 22 x 9 ft. The furnace is 6 ft. deep. The furnace is operated on 60-cycle, three-phase alternating current. Two 24-in. round electrodes are used in a common holder on each phase. The electrodes are spaced 6 in. apart in the holders and the pairs about 5 ft. on centers.

Electric power is delivered at 100,000 volts from nearby hydro-electric plants of the Montana Power Co. and is transformed to furnace voltage, 115 volts, in two steps, 6600 volts being the intermediate point. Each furnace is equipped with one General Electric polyphase transformer rated at 5630 kva. Each furnace has a rated power consumption of 3500 kw. and an output of 18 tons of 80 per cent alloy daily.

A very considerable quantity of carbonate ore of the following approximate analysis has already been blocked out in the upper levels of several of the Butte mines belonging to the Anaconda Copper Mining Co.

Moisture	1.82 per cent
Manganese	35.89 "
Silica	9.34 "
Iron	2.0 "
Alumina	2.15 "
Magnesia	2.50 "

Six parts of this ore will be reduced by two parts of a local bituminous coal; the mixture will also contain about one part limerock to flux the impurities in the ore and coalash. Sufficient iron ore will also be charged to bring up the iron content in the resulting metal. The proper mixture is delivered to charge hoppers by overhead crane, the furnaces themselves being built in the north end of the main smelter building opposite the abandoned copper blast furnaces.

Metal and slag are tapped together into pots. The waste slag is skimmed and the metal cast by a casting machine formerly in use for casting copper.

E. S. BARDWELL, superintendent of the ferro-alloy department of the Anaconda company, hopes to have the five furnaces running to capacity within six weeks, when he will have the world's largest ferromanganese plant in operation. About seventeen pounds of 80 per cent ferro is required to deoxidize a ton of open-hearth steel; thus the daily production of ninety tons at Great Falls will annually satisfy the requirements of 3¾ million tons of mild steel. An idea of the importance of this one plant may be had from the statement that its production will care for 8 per cent of the entire yearly production of steel ingots in the United States and will release six or seven 5000-ton ships from transporting Brazilian manganese ore to this country.

Iron and Steel Metallurgical Society

THE need for a metallurgical society exclusively confined to the metallurgy of iron, steel and their alloys has been keenly felt for a long time. Metallurgists prominently connected with this branch have from time to time expressed themselves to this effect. Recently several of them discussed the matter in a definite way at a meeting held in the Fort Pitt Hotel, Pittsburgh, when the formation of a society was decided upon. Its aim and object is the promotion of the arts and sciences connected with the metallurgy of iron, steel and their alloys.

A committee to consummate the plans of this meeting was appointed, of which Mr. D. L. MATHIAS of Mackintosh, Hemphill & Co. was selected as chairman, who are taking steps to materialize the society. Before the society can be a real force, the active co-operation of those eligible for membership will, of course, be needed.

The committee will be pleased to answer inquiries and furnish information to those interested.

Operation at Grand Forks—A Correction

In our issue for Oct. 15, 1918 (Vol. 19, p. 606), the statement was made in error that the Grand Forks smelter had been shut down. Mr. W. A. WILLIAMS, supt. of smelters for the Granby Consolidated, informs us that the plant continues to operate three furnaces, since smelting at this point has been successfully maintained irrespective of the grade of ore so far available.

Muscle Shoals Nitrate Plant

Description of the Largest Synthetic Nitrogen Works in the World—Cyanamide Process—Lime and Coke, Carbide Furnace and Milling, Liquid Air, Oxygen and Nitrogen, Ammonia, Catalytic Oxidation and Nitric Acid Departments Detailed

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MILITARY explosives may be divided, according to the uses to which they are put, into two classes: Propellants for hurling projectiles, and high explosives for bursting the bombs or shells. Both classes are nitrogen compounds made from nitric acid or ammonia or both. The propellants are made by treating cotton or glycerin with nitric acid, and the bursting explosives are made by treating toluol, benzol or ammonia with nitric acid. The names of the three most important bombing or shell-bursting explosives are trinitrotoluol (TNT), trinitrobenzol (picric acid) and ammonium nitrate. Since the cost of either TNT or picric acid is about two and one-half times the cost of ammonium nitrate, it became plainly important, soon after the United States entered the great war, to increase the supply of nitrate of ammonia in this country as rapidly as possible.

At the same time it became distressingly evident to the chemists of the country that this nation was entirely dependent upon a foreign country for its supplies of the only chemical from which nitric acid could be made in quantity. This chemical—nitrate of soda—had to be imported over thousands of miles of ocean from Chile, and it was forcefully realized that if this country should become involved in war with any nation which could gain control of the seas and thus cut off our supplies of nitrate of soda, we would be unable to make ammunition, and hence we would be at the mercy of a foreign power. Added to this was the knowledge that a large fleet of ships was required to transport from Chile the large tonnage of nitrate of soda so urgently needed for munition-manufacture, ships which were sorely needed for the transport of troops and supplies to France and could not well be spared for the long journey to South America. Furthermore, the manufacture of nitric acid from nitrate of soda requires the consumption of large quantities of sulphuric acid, of which there was already a serious shortage.

STEPS TO OVERCOME VULNERABLE POSITION

In this emergency and with the realization that the output of a plant for the manufacture of nitrates could be used in time of peace for fertilizers as well as in time of war for munitions, the Ordnance Department determined to correct the vulnerable position of the country and to render the United States independent of foreign countries for the manufacture of nitric acid and nitrates.

Since in this country no extensive beds of natural nitrates exist, artificial nitrates had to be made, and the only existing sources were (1) the gases of the by-product coke ovens, and (2) the nitrogen of the atmosphere.

The capacity of by-product coke ovens had already been doubled since August, 1914. The cost of construction of these ovens had risen to about two and one-half times the normal cost. To furnish the amount of ammonia needed from this source could have required another doubling of capacity, at an expenditure of money and consumption of valuable time which would have been intolerable. The only practical source of artificial nitrates appeared to be the unlimited quantities of nitrogen in the atmosphere.

In the fall of 1916, Dr. Charles L. Parsons, Chief Chemist of the Bureau of Mines, who had been sent abroad to investigate European methods for the fixation of atmospheric nitrogen, returned to this country and submitted his report.

IMPORTANT PROCESSES FOR FIXATION OF ATMOSPHERIC NITROGEN

The three most important processes in commercial use were known to be the arc process, the Haber process, and the cyanamide process. In the arc process air is blown through a flaming electric arc which burns the nitrogen to nitric oxide, and this is absorbed in water or milk of lime to make nitric acid or nitrate of lime. Its successful use has been limited to localitites such as exist in Norway, where enormous hydro-electric power can be generated at very low cost. There is no water-power site in this country which can compete as to cost of power generated with the Norwegian sites. The Haber process combines nitrogen and hydrogen, mixed in the right proportions for chemical combination, at a very high temperature and pressure, by means of a catalyzing agent, thus forming gaseous ammonia, which can be burned by passing through incandescent platinum gauze to form oxides of nitrogen, which in turn can be passed through towers sprayed with water to form nitric acid. The practicability of producing ammonia and nitric acid by a modification of the Haber process had already been a subject of investigation by the Nitrate Supply Committee of the War Department, and a plant using this process to be erected at Sheffield, Alabama, with a capacity equal to 22,000 tons of ammonia nitrate per annum, had been contracted for. This plant, known officially as U. S. Nitrate Plant No. 1, was being built under a Congressional appropriation of $20,000,000. It was also planned to test several other new processes at No. 1 Plant. However, none of the processes to be tested at Plant No. 1—not even the modified Haber process—had ever been operated successfully on a commercial scale[1] and could not therefore be fully depended upon; therefore, the Ordnance De-

[1]The true Haber process, said to be operating successfully in Germany, was not known in this country in all its details.

partment was unwilling to commit itself to the extension of any of these uncertain processes, and instead resorted to a consideration of the cyanamide process.

The Cyanamide Process

The dependability of the cyanamide process had already been proved by actual commercial operations over a period of years. Cyanamide had been manufactured continuously since 1909 at Niagara Falls, Canada, and since the outbreak of the war the plant there had had a capacity of 64,000 tons per annum. A considerable part of the cyanamide produced had been converted into ammonia since the early part of 1915 and had been used in producing ammonium nitrate for the Allies. A plant for the oxidation of ammonia, produced from cyanamide, to nitric acid had also been in continuous operation on full-sized equipment for more than a year. The patents for producing chemicals by the cyanamide processes were controlled by the American Cyanamid Co.

With these facts in mind the Ordance Department, in the fall of 1917, invited the American Cyanamid Co. to present some plan for the manufacture of ammonium nitrate on a large scale. The plan presented was for the manufacture of ammonium nitrate from air, steam and water, by means of the common materials limestone, coal and coke. One or more plants, it was shown, each complete in itself, could be built within twelve months to supply the entire quantity of ammonium nitrate desired. There was to be nothing experimental or untried about the project. All that would be required would be to reproduce, on any scale desired, the several elements of existing installations successfully operating. The cost of construction would be only a small fraction of the cost of building by-product coke-ovens of equal ammonia capacity.

At the request of the War Department the American Cyanamid Co. formed a subsidiary company, known as the Air Nitrates Corporation, to act as the agent of the United States Government for the construction and operation by the cyanamide processes of a plant at Muscle Shoals, Alabama, to produce 110,000 tons per annum of ammonium nitrate. This plant is known as U. S. Nitrate Plant No. 2, to distinguish it from Nitrate Plant No. 1, referred to above.

U. S. Nitrate Plant No. 2

Nov. 16, 1917, was the date on which it was decided to construct the new plant. The first carload of material was delivered on Dec. 20 the same year, and the first ground was broken on Feb. 16, 1918. Since then more than 20,000 men have been employed on construction of the plant. The site for Nitrate Plant No. 2 is on the Tennessee River at Muscle Shoals, in the northwest corner of the State of Alabama, between the towns of Sheffield and Florence. The nearest railroad station is at Sheffield, some three miles away, served by the Louisville & Nashville Railroad and the Southern Railway. The site occupies 2,200 acres, including a permanent town built to accommodate 12,000 people, composed of two communities, one for white people and the other for negroes. Temporary quarters had to be rushed first, however, for the thousands to be employed in construction work, and by May a mushroom city of 20,000, with lodgings, restaurants, offices, police headquarters, hospitals, motion-picture theatres, telegraph, telephone, electric light and sewerage systems and many other necessities and conveniences of modern urban life, covered the ground which had been growing corn and cotton or over which the native Alabaman had hunted the rabbit and raccoon the preceding fall.

Ten Operating Departments

The complete plant includes ten operating departments, each housed in one or more separate buildings, an office, shops, laboratories and other general service buildings. The important operating departments are as follows:

1. The power plant.
2. The carbide-materials department.
3. The carbide-furnace department.
4. The carbide-mill department.
5. The nitrogen department.
6. The lime-nitrogen department.
7. The lime-nitrogen-mill department.
8. The ammonia-gas department.
9. The nitric-acid department.
10. The nitrate department.

The entire plant is so laid out that beginning at the carbide-materials department, located some 3600 feet south of the Tennessee River, the main product of each department will proceed to the next department continuously from north to south, in the order named above. An exception to this rule is the nitrogen department, which, producing a material to be used first in the lime-nitrogen department, has been placed far to the east of the lime-nitrogen building, for reasons to be explained later.

The Power Plant

Ultimately, power for Nitrate Plant No. 2 will be furnished by the large hydro-electric plant to be constructed by the Government on the Tennessee River at Muscle Shoals. This proposed hydro-electric plant will form the subject for a long story in itself. It will suffice here to say that the development of this power will necessarily consume so much time that Nitrate Plant No. 2 could not wait for it, and it was decided to build a steam plant for use in the interim. The hydro-electric plant being therefore not essential for the operation of the nitrate plant, work on it was discontinued some months ago; but since the signing of the armistice with Germany it has been announced that this work has already been resumed.

The electric requirements of the various departments of the Nitrate Plant are estimated at 90,000 kw., 60,000 of which will be furnished by the large steam plant now under construction, and 30,000 will be generated by the Alabama Power Co. in a Government-owned extension to the Warrior steam power plant of that company situated in the Alabama coal fields at Gorgas on the Warrior River and transmitted 88 miles to the plant.

Steam-Power Plant Designed to Develop 90,000 Kilowatts

The steam power plant of Nitrate Plant No. 2 is located on the south bank of the Tennessee River about 3600 ft. north of the nearest plant building. It has been designed to develop, if necessary, the entire 90,000 kw. needed, by means of two units, Unit 1 of 60,000

kw. capacity, and Unit 2 of 30,000 kw., but in view of the resumption of work on the Tennessee River power development, it is not likely that the equipment for Unit 2 will ever be installed.

The boiler room (158 ft. 9 in. x 228 ft. 6 in.) will contain the 12 boilers of Unit 1, B. & W. Stirling type, water tube, each developing 1500 hp., and each equipped with B. & W. superheater and Diamond soot blower. The steam end of Unit 1 will be subdivided into three units of 20,000 kw. each. The turbine room is 170 ft. x 88 ft., equipped with Westinghouse turbines and generators—the latter A.C., 60 cycle, 3-phase, 12,200 volts. The turbines will be operated by steam at 275 lbs., 175 deg. F. superheat, and 28.5 in. of vacuum. The electrical accessory room (191 ft. x 35 ft.) will contain the necessary motors, batteries, rheostats, etc. The power house equipment includes also the necessary blowers for forced draft on the boilers, pumps, condensers, etc. Water for the condensers is taken from a coffer dam in the Tennessee River just north of the plant. Coal is brought into the plant in hopper-bottom cars on an overhead track, and is dumped into crushers, and the crushed coal is carried by screw-conveyors to the bunkers.

On Nov. 15 much work still remained to be done on the installation of the equipment of the power house, but it was then expected that the first 20,000 kw. subdivision of Unit 1 would be operating by Jan. 1.

Bus-Tunnel

The electric current at 12,000 v. will be transmitted from power-house to plant through a special bus-tunnel. This tunnel (built on the surface for the greater part of its length and underground for only about 200 ft.—at the point where railroad tracks will cross it) is 22 ft. 10 in. wide x 8 ft. high x 3600 ft. long. It is built of brick and concrete and has a gable roof of concrete

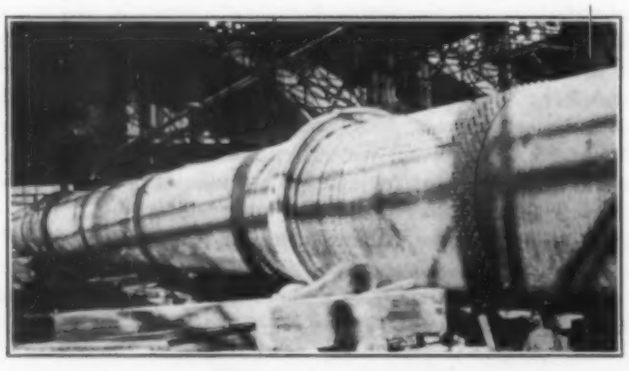


FIG. 1. ONE OF THE LIMEKILNS

slabs, covered with 3-ply felt and tar. Pent-houses at intervals of about 500 feet afford ventilation and means of access to the compartments of the tunnel. There are three compartments extending the entire length of the tunnel, separated by concrete walls. The two outside compartments are 5 ft. 8 in. wide inside and the middle compartment 8 ft. 10 in. wide. Attached to the concrete dividing walls are insulators which support the copper bus-bars. Each of the two dividing walls carries two bus-bar circuits—one circuit on each side of the wall. Thus there is one circuit in each of the two outside compartments of the tunnel, and two circuits in the middle compartment. Each circuit consists of 3 buses, supported one above the other on the wall and about one foot apart, and each bus is composed of two horizontally parallel copper bars, each ¼ in. thick x 4 in. wide. Expanded metal screens two feet away from the bus-bars will prevent persons who may be in the tunnel from coming in contact with the high voltage circuits, and will provide a safe passage for attendants or workman, 4 ft. 10 in. wide in the middle compartment, and 3 ft. 8 in. wide in the two outside compartments. Safety signals will also be provided to indicate whether the bars are alive or not. Provision has been made also for fire-doors by means of which one section of a compartment may be shut off from another.

At its upper end the tunnel terminates at the switch-house, where the electric current is diverted to the various departments requiring power.

The Carbide-Material Department

The purpose of the carbide-material department is to produce the quicklime and the crushed coke required by the carbide-furnace department, and its main functions are:

1. To pulverize the coal for the limekilns and coke driers.
2. To calcine (or burn) limestone in the limekilns, to form quicklime.
3. To crush and dry coke.

The limestone, quarried and crushed to sizes of from ½ in to 2 in. at the Government quarries at the Rockwood District near Russellville, Alabama (28 miles distant), is discharged from cars on a track at the north end of the limekiln building. The unloading of the cars is done either by dumping from drop-bottom cars or with the locomotive crane, as may be required. The crushed and sized limestone is carried by a conveyor belt to a bucket elevator, by means of which it is hoisted to an upper floor and distributed by means of a conveyor belt among seven concrete silos or bins, each of 6000 cu.ft. capacity.

A typical analysis of this limestone is:

Silica (SiO_2)	0.49 per cent
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	0.30 per cent
Calcium carbonate ($CaCO_3$)	98.23 per cent
Magnesium carbonate ($MgCO_3$)	0.97 per cent
Moisture and loss on heating to 175 deg. C.	0.07 per cent
Total	100.06

From the silos the limestone goes to a cradle feeding device, made by the Fuller Car-Wheel Manufacturing Co. of Catasaqua, Pa., which regulates the flow of limestone into the limekiln.

The limekilns are seven in number, each 8 ft. in diameter and 125 ft. long. Four of them were made by Reeves Bros., Alliance, Ohio, and the three others by the Allis-Chalmers Co. Fig. 1 is a photograph of one of these kilns. The kilns are nearly horizontal, having a pitch of 5 ft. in 125 ft. of length. They are steel shells lined with fire brick, and are rotated at the rate of about ½ r.p.m. by means of a beveled gear. The limestone is fed in at the upper end, and at the lower end the kilns are fired with powdered coal by an air blast. The temperature in the kiln is from 1400 to 2000 deg F. The product is quicklime and the reaction which takes place in the kiln may be expressed thus:

$$CaCO_3 = CaO + CO_2.$$

The process is continuous, but from three to four hours are required to complete the burning of the limestone. The capacity of the kilns is about 200 tons of

raw limestone per day each, equivalent to about 100 tons of burned lime. When the plant is fully tuned up, the combined capacity of the seven kilns will be from 1400 to 1600 tons of limestone per day.

From the limekilns (or limestone-burning kilns) the quicklime is discharged into seven horizontal cooling kilns, each 5 ft. in diameter and 50 ft. long, which revolve at the rate of about 3 r.p.m. The cooled quicklime is then conveyed to the raw materials building.

The coal-mill building (50 ft. x 125 ft.) situated alongside the kiln building, contains a coal bin, from which the coal is delivered to a crusher, thence to a steel silo, then to a coal drier. The latter is a rotary steel shell 42 ft. long x 3.5 ft. in diameter, fired externally by hand. The dried coal is carried up by elevator to steel silos from which it is fed to four Fuller 42-in. pulverizer mills. Thence it is carried up an elevator to a screw conveyor which takes it to small steel silos of which there is one opposite each limekiln. From these it is fed as needed, by means of an air blast, into the limekilns to effect the burning of the limestone.

At the coke-drier building, just east of the limekiln building, coke is dropped into hoppers underneath the track, and conveyed by belt conveyor to two crushers, where, after screening, the coarse is crushed to nut size and the crushed coke is then conveyed to two concrete silos, capacity 15,400 cu.ft. each, and thence fed down into four rotary driers, fired with coal. After drying, the coke is carried by belt conveyor to eight silos (capacity 6600 cu.ft.) in the raw-materials building, for use in the carbide-furnace department.

The raw-materials building (52 ft. 8 in. x 102 ft. 8 in.), located next to the limekiln building and south of it, is for the storage of the crushed coke and the quicklime, and designed to keep these materials as free from dampness as possible. From the bins in this building the materials are weighed in the desired proportions and mixed. The weighing apparatus beneath the two bins at the south end of the building consists of two 36-in. Schaffer poidometers, manufactured by the Schaffer Engineering and Equipment Co., of Tiffin, Ohio. These operate continuously, one for limestone and one for coke. They can be set to weigh the exact proportion desired, and both limestone and coke are delivered to the same conveying belt and carried to the carbide room.

Beneath the other bins there are three 8000-lb. scale hoppers, arranged for weighing either limestone or coke. The materials go from the scales to a conveying belt, to a bucket elevator, to another conveying belt, then in the carbide-furnace building are distributed among 24 steel silos, whence the charge, already mixed, can be dumped through chutes on to the charging floor of the carbide furnaces.

Carbide-Furnace Department

In the carbide-furnace building quicklime and dried crushed coke are heated to high temperature in an electric furnace, to form calcium carbide (CaC_2).

The size of the carbide-furnace building is 90 ft. x 1050 ft. and nine-tenths of this space is occupied by the carbide furnaces and their equipment. The building is the next building south of the raw-materials building, and its length extends from east to west, and its width from north to south. The carbide furnaces, of which there are twelve, are rectangular in shape, 12 ft. x 22 ft. x 6 ft. deep inside. They are merely steel boxes, open at the top and lined with firebrick.

At the east end of the carbide-furnace building there is a room 90 ft. x 100 ft. set apart for the assembly of the electrodes for the furnaces. The electrodes reach this room in the form of carbon blocks 16 in. square x 6 ft. 5 in. long. The assembly of electrodes consists in the following process: An area is planed at each side of one end of these carbon blocks, so that a metal head may make a good electrical contact. At the same end of each carbon block two holes are bored, and a copper electrode head is secured to it by special bolts. Then three of these blocks are fastened together as a unit and covered by wire netting and a protecting layer of heat-resisting cement (a mixture of asbestos and retort cement) which is baked on in an electric furnace. One complete electrode, assembled as described, weighs 7000 lb. Pipe connections are made to the electrode heads, which are provided with a water-cooled system, for cooling the electrodes while in service.

Three of the complete assembled electrodes are suspended from suspending arms over the top of the furnace. The depth of immersion of the electrodes in the molten bath is controlled automatically on the electric switchboard. The bus-bars carrying current to the electrodes are $\frac{5}{16}$ in. thick x 8 in. wide, and there are 16 bars to each electrode. The voltage for the carbide furnaces is 130 v. stepped down from 12,000 v. by G. E. transformers. There is one bank of transformers for each furnace, the capacity of each bank being 8325 kw. The current used at present is 15,000 amp., but when operating normally the current will be 20,000 amp. The normal capacity per furnace is 50 tons per day of 24 hours. The temperature attained in the furnace is 3000 deg. C. During the reaction the electrode is consumed at the rate of 70 lb. of carbon per ton of carbide manufactured. The reaction may be expressed thus:

$$CaO + 3C = CaC_2 + CO$$

The carbon monoxide burns at the top of the furnace and escapes as carbon dioxide.

On the bottom of the furnace is placed one layer of graphite electrodes, 16 in. square x 48 in. long. On top of this layer of electrodes is placed a layer of tar and gravel. In starting a furnace, a layer of crushed coke is thrown in on the bottom. The charge is put in on top of the layer of coke and the current is turned on. The charge consists of a mixture of quicklime and dried crushed coke, in the proportions of 1000 lb. of the former to 600 to 620 lb. of the latter. This mixture is made up in the raw materials building and conveyed to the charging floor of the carbide furnaces as previously described, and is shoveled into the furnace until it is full to the top. The first tap is made six hours after starting, and thereafter the furnace is tapped every 45 minutes, the furnace being kept full to the top all the time by men on the charge floor, shoveling in the mixture as required.

The furnace is tapped by burning out the tapping hole with a portable electrode, whereupon the molten carbide flows out into "chill cars" of one-half ton capacity each. After tapping, the tapping hole is stopped by throwing a few shovelfuls of powdered carbide at

the outlet. The outflowing mass soon solidifies and the flow is stopped. The chill cars containing the hot carbide are hauled by electric locomotives operated by storage batteries to the carbide-cooling building, which is a part of the next department.

Carbide-Mill Department

The carbide mill department is responsible for cooling, crushing and pulverizing of the carbide for use in the lime-nitrogen department. The carbide-cooling building (950 ft. long x 50 ft. wide) is located south of the carbide-furnace building and parallel to it, and is connected to it by six passageways each 50 ft. x 50 ft. As contact with water will produce acetylene, care must be taken in cooling to protect the carbide from rain and snow. The buckets containing the carbide pigs are picked off the cars by a traveling crane, and set aside to cool. During the process of cooling, considerable shrinkage takes place; when sufficiently cooled, the pigs or blocks of carbide are dumped out of the buckets on to the crusher platform.

The following is a typical analysis of the manufactured carbide:

CaC_2	82.30 per cent	Ca_3P_2	0.07 per cent
C	1.20 per cent	CaS	0.13 per cent
CaO	14.72 per cent	FeSi	0.72 per cent
CaSi	0.06 per cent	Undetermined.	0.80 per cent

The carbide-crusher building (120 ft. x 150 ft.) contains three 36-in. x 42-in. Buchanan crushers, which crush the carbide to about 1¼-in. size. After crushing, the material goes by elevator to a bin which supplies the Hardinge mills, of which there are three. These grind the carbide so fine that 80 per cent of it will pass through a 40-mesh screen, and the balance through a 10-mesh screen. From the Hardinge mills the powdered carbide goes to three Smidth tube mills, which pulverize the carbide still further, so that 85 per cent will pass through a 200-mesh screen, and the product is known as milled carbide.

While going through the process of milling, the carbide must be protected from the moisture of the air, which, acting on the finely divided carbide, might react with it, forming acetylene, a gas of an explosive or inflammable nature when mixed with air. The grinding and milling of the carbide are therefore done in an atmosphere of nitrogen, this inert gas being piped to the carbide-crusher building from the liquid-air building, for use in the grinding and pulverizing mills.

The milled carbide is conveyed to eight steel bins or storage silos in the lime-nitrogen building. The pulverized carbide constitutes only one of the two important raw materials for the manufacture of lime nitrogen; the other one is the nitrogen.

Nitrogen Department

The nitrogen is obtained from air in the liquid-air building. The process, described briefly, consists in the compressing and cooling of air until it becomes liquid, then in the fractional distillation of the liquid air to separate the nitrogen from the oxygen in much the same manner as alcohol is separated from water, advantage being taken of the different temperatures at which the two gases change from the liquid state to the gaseous.

The liquid-air building (100 ft. wide x 575 ft. long) is located ¼ mile to the east of the lime-nitrogen building. The object of this isolation is to have the air intakes and the equipment of this department away from the contaminating gases of the other departments of the plant.

The air intakes for the liquid-air process consist of two 36-in. pipes, which extend, one north and the other south, for 1600 ft. in either direction, from a point opposite the center of the building, on the east side, for the sake of getting a supply of pure air. By means of Root cycloidal blowers the air is drawn through the intakes and then is forced through eight sets of scrubbing towers (two towers to a set). These towers, 8 ft. in diameter and 30 ft. high, are packed with 6-in. spiral rings. The towers are fed with a solution of caustic soda (17 deg. Bé.), a fresh solution to each tower. The object of the scrubbing of the air is to remove impurities, chiefly the 0.04 per cent of carbon dioxide, which, if not removed, would give trouble in the subsequent operations by freezing. The caustic liquor discharged from the scrubbers goes to the ammonia-gas department, where the carbonate is removed, and the caustic solution made up to strength and returned to the liquid-air department. From the second towers the air goes to the main header, and is thence supplied to the compressors.

The Liquid-Air Plant

The engineer who designed the liquid-air plant is Herman Van Fleet of Philadelphia. Fundamentally the process used is the Claude process. There are 15 twin-duplex compressor units, furnishing air at 600 lb. pressure to 30 nitrogen columns. Seven of these compressors were furnished by the Ingersoll-Rand Co. and eight by the Norwalk Iron Works. The compression is done in three stages: 30 lb., 140 lb. and 600 lb. Of the 30 nitrogen columns, 24 will be operating normally—the six others being spares. The nitrogen columns were made by the Ansonia Brass and Copper Co., Cincinnati, Ohio, and the rights to their use are controlled by the Air Reduction Co. The columns, oval in shape, are about 4½ ft. in diameter and 24 ft. high. The rectifier in the nitrogen column consists of a series of superposed horizontal trays, each about 1½ in. deep, on which rests a body of liquid through which the rising gas must bubble.

The compressed air from the Norwalk or Ingersoll-Rand compressors is allowed to expand from 600 lb. to 50 lb. In expanding, the air operates a small engine, generating thereby about 4 to 5 hp., this power going to waste. The air at 50 lb. pressure enters the rectifier, and at this stage is below the critical temperature of air (—140 deg. C.). A small part (about one-tenth) of the air at 600 lb. is admitted to the rectifier at that pressure, and the increased pressure on the cold air at 50 lb. pressure liquefies the air. The liquid air then begins to distil. Oxygen liquefies at —182 deg. C. and nitrogen at —195 deg. C. Oxygen, therefore, tends to remain liquid, and the nitrogen tends to go over into the gaseous state. Therefore, a liquid rich in oxygen (45 to 50 per cent O) is found at the bottom of the rectifier, and the gas in the rectifier gradually becomes richer in nitrogen as it approaches the top. At the top of the rectifier the gas is sprayed with liquid nitrogen, and gaseous nitrogen, 99.9 per cent pure, escapes.

Tests of the percentage of oxygen in the gas mixture inside the rectifier are made from time to time, for regulation of the apparatus.

The nitrogen is passed through two pipe heat-exchangers, to recover the cold, then goes to the nitrogen header, then through a 30-in. main to the lime-nitrogen building. The nitrogen escapes from the rectifier under a pressure of 10 in. of water and goes to the lime-nitrogen building under a pressure of 4 in. of water. Each nitrogen column produces nitrogen at the rate of 500 cu.m. (1765 cu.ft.) per hour. The oxygen is passed through the heat-exchanger and is then allowed to escape into the atmosphere of the building.

The illustration (Fig. 2) is a photograph of the interior of the liquid-air building. In the middle foreground is one of the nitrogen columns with its engine and heat-exchangers and other nitrogen columns can be seen farther to the right. At the left, in the background, is one of the duplex-compressor units.

The compressors for the service air for the entire nitrate plant have for convenience been installed in the liquid-air building, at the north end. For furnishing service air there are five Sullivan two-stage angle compound air compressors, furnishing air at 100 lb. The air goes to the compressors through a 28-in. intake, and is delivered to the plant through two 10-in. mains, which are so connected that one can be shut down for repairs if necessary without interfering with the air service to the plant. These five compressors have a combined capacity of 10,000 cu.ft. of free air per minute.

Lime-Nitrogen Department

The lime-nitrogen building is 250 ft. wide and 520 ft. long, and is located south of the carbide-mill building. In this building the milled carbide and the nitrogen are brought together to form lime nitrogen, commercially known as crude cyanamide.

There are sixteen rows of lime-nitrogen ovens and 96 ovens in a row—1536 ovens in all. Eight rows of the ovens are located on the west side of the building, occupying 100 ft. of the width, and the other eight rows on the east side likewise occupy a space 100 ft. wide, leaving a space 50 ft. wide in the center, extending from north to south, which is used for the manufacture of the paper containers and tubes employed in charging the ovens.

The ovens are 4 ft. 4 in. outside diameter x 2 ft. 10 in. inside diameter x 5 ft. 4 in. deep. They consist of a steel shell with a 9-in. lining of Evans & Howard fire-brick. To charge the oven a cylindrical paper container 2 ft. 6 in. in diameter, with a vertical paper tube 3 in. in diameter in the center, is inserted in the cold oven, and the charge of about 1600 lb. of pulverized carbide is put in. There will be an annular space about 2 in. wide between the paper container and the brick lining of the oven. The carbon electrode, a ¾-in. pencil 6 ft. 6 in. long, is inserted inside the paper tube. Two covers are put on, the outer cover being luted with sand.

For bringing the nitrogen to the ovens there is an 8-in. spiral riveted pipe between each pair of parallel rows of ovens, and from this two 1¼-in. pipes convey the nitrogen to the oven—one to the bottom, at the center, and the other at the side, 6 in. above the bottom—each provided with a valve. The nitrogen reaches the oven under a pressure equal to 3 to 4 in. of water.

When everything is ready, the electric current (single phase) is turned on at 100 volts and 200 to 250 amp. for 20 minutes, then it is reduced to 50 volts and 100 to 115 amp. for 12 hours. Then, as the reaction is exothermic, the current is shut off and the reaction allowed to continue 28 hours longer. The temperature

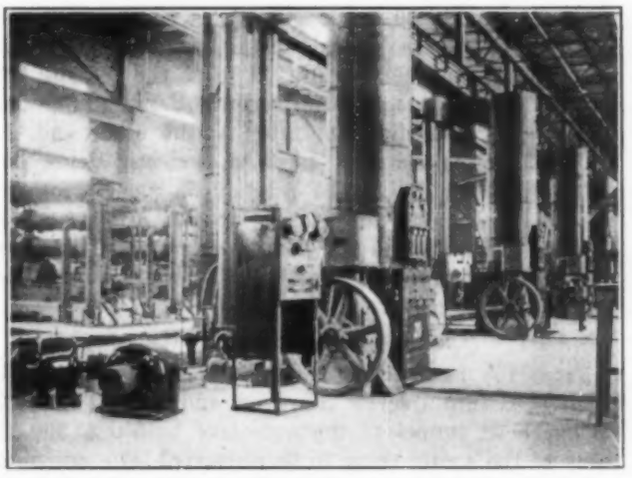


FIG. 2. NITROGEN COLUMNS, LIQUID-AIR BUILDING

attained in the oven is about 2000 deg. F. The material is not melted, but sinters together to form a solid cake.

In the oven the nitrogen is absorbed by the carbide, and carbon is set free, the chemical equation being:

$$CaC_2 + N_2 = CaCN_2 + C$$

A typical analysis of the lime nitrogen follows:

$CaCN_2$	63 per cent	SiO_2	3 per cent
CaC_2	2 per cent	MgO	2 per cent
CaO	13 per cent	Fe_2O_3 and Al_2O_3	2 per cent
CaS	1 per cent	Miscellaneous	3 per cent
C	11 per cent		

For removing the cakes or blocks of lime nitrogen, and otherwise serving the ovens, an industrial track has been provided in the building with cars drawn by gasoline locomotives. The finished cyanamide is taken to the lime-nitrogen-mill department for cooling.

Lime-Nitrogen-Mill Department

The lime-nitrogen-mill department has three functions to perform:

1. To cool the cyanamide pigs.
2. To crush and mill the cyanamide.
3. To remove from the cyanamide some of the undecomposed carbide by a hydration process.

The lime-nitrogen-cooling building (50 ft. x 350 ft.) is at the south end of the lime-nitrogen-oven building. It is served by two 20-ton Whiting cranes. The cooling of the cyanamide blocks does not require as much care as was the case with the carbide pigs, as the material does not now combine readily with water to form acetylene gas. After cooling, the cyanamide blocks are crushed and pulverized.

The cyanamide-mill building is an exact duplicate of the carbide-mill building. The cyanamide is pulverized so that 95 per cent will pass through a 200-mesh screen.

All grinding and pulverizing is done in an atmosphere of nitrogen. The milled cyanamide is taken to nine large concrete silos in the lime-nitrogen-silo building (56 ft. sq. x 76 ft. high), south of the mill building. From these silos the material goes to the hydrating building (size 50 ft. x 80 ft.). Here the milled cyanamide is conveyed by screw conveyors to an elevator and thence to a hopper-feeding device, which feeds so many pounds per hour to the hydration troughs. There are three of these, 36 ft. long x 3 ft. in diameter, open top, and each containing a horizontal revolving shaft with many projecting arms 20 in. long. Water, in amount proportional to the free carbide in the cyanamide as shown by chemical analysis, is sprayed in at the feeding end of the trough. The material becomes damp and is conveyed by the revolving agitator to the other end, by which time the material must be perfectly dry. The agitator, revolving at the rate of 50 r.p.m., conveys the material along the trough at the rate of about 50 ft. a minute. The acetylene liberated in the hydration building goes to waste. The reaction in the hydration trough is:

$$CaO + CaC_2 + 3H_2O = 2Ca(OH)_2 + C_2H_2$$

From the hydrating troughs the dry cyanamide is discharged into a screw conveyor, and carried through an overhead tunnel to the autoclave building, 300 ft. away to the south, there to be converted into ammonia.

Ammonia Gas Department

The principal building of this department is the autoclave building, but auxiliary apparatus is contained in the process boiler house and in the filter building, while the dephlegmators and steam condensers are out-of-doors, between the autoclave building and the process boiler house.

The latter must not be confused with the main power house, which was described at the beginning of this article. The process boiler house is to furnish steam for the autoclaves, also for heating the various plant buildings. It is located about 100 ft. to the east of the autoclave building. The equipment consists of four 825-hp. B. & W. Stirling type boilers, with the necessary feed-water pump and water-measuring apparatus. The boilers are fired by Westinghouse stokers from overhead bunkers. Coal is delivered to the boiler house on a track north of the building, and is dumped into a hopper beneath the track, and conveyed to a crusher, then elevated to the bunkers. The operating pressure of these boilers is 150 lb.

The autoclave building (81 ft. x 252 ft.) contains the autoclaves for the manufacture of ammonia from cyanamide. The autoclaves are cylindrical steel tanks, 8 ft. in diameter and 20 ft. high, each provided with a vertical agitator, which revolves at the rate of 12 r.p.m. throughout the continuance of the reaction. There are 56 autoclaves in all, made of 1¼-in. steel by M. W. Kellogg, New York.

The milled cyanamide, arriving at the autoclave building, is hoisted by a bucket elevator to an upper floor, and dumped into a steel silo. From this it is fed into 14 hopper bins, and these discharge into weigh bins. Each weigh bin feeds into a 5-in. screw conveyor, which in turn supplies a 12-in. screw, delivering to 4 autoclaves.

Before charging any cyanamide into the autoclave, a 2 per cent solution of caustic soda is run in to a depth of 9 ft. Then about 300 lb. of soda ash is added. Since the cyanamide carries about 13 per cent of free lime, the latter reacts with the soda ash to form some additional caustic soda, thus making the solution equivalent to 3 per cent in strength. After the addition of the soda ash the charge of cyanamide, 8000 lb., is admitted. The cyanamide, even after leaving the hydration building, still contains about 2 per cent of undecomposed calcium carbide, so that the first reaction in the autoclave, when the lime nitrogen comes in contact with the caustic soda solution, results in the generation of acetylene. All valves on the autoclave are closed except one, and through that one the acetylene is allowed to escape through an exhaust fan. After all of the acetylene has passed off, the outlet pipe is shut and clamped tightly. Then steam is admitted at a pressure of 150 lb. for 20 minutes. Ammonia gas begins to form in the autoclave. The reaction is exothermic. When the pressure in the autoclave rises to 250 lb., the ammonia escape valve is opened cautiously, but the pressure is maintained constant for 3 hours. By this time the pressure begins to fall off, and the ammonia is allowed to escape. The ammonia valve is closed again and steam is admitted a second time for 20 minutes. The reaction continues this time at 200 lb. pressure for an hour and a half. The chemical reaction in the autoclave is expressed:

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$$

This operation must be carefully controlled to prevent the pressure from rising too high, which would result in loss of valuable ammonia through the safety valves.

The gas escaping from the autoclaves (about 25 per cent ammonia and 75 per cent steam) goes to a header at the north end of the building, then to seven mud drums, then to seven dephlegmators, or ammonia columns. These are about 10 ft. in diameter and 25 ft. high, and each contains 16 horizontal plates. The gas enters at the bottom, and rising through 4-in. holes in the plates, covered with bell-shaped caps, bubbles through ammonia liquor standing on the plates or shelves. The gas then goes into 14 condensers (seven sets with two connected in series to each set). The condensers contain vertical tubes through which water circulates, and here the steam is condensed. The ammonia gas then goes to a 28-in. pipe, which is tapped by two 20-in. mains, one of which conveys 55 per cent of the ammonia to two 60,000-cu.ft. receivers, to supply the catalyzer plant, while the other carries 45 per cent of the gas to the neutralizer building. The capacity of the plant is 1000 tons of ammonia gas per week.

The Filter Room

A quantity of sludge, consisting chiefly of carbonate of lime, caustic soda, free carbon, etc., remains in the autoclave, and must be removed before recharging. An 8-in. outlet at the bottom of the autoclave permits the sludge to be blown out with steam or air. It flows by gravity to the filter room (151 ft. x 160 ft.) adjoining the autoclave building, where it is treated for the recovery of the caustic soda. In the filter room there are two sets of Oliver rotary filters, ten filters to a set. Each of the four sludge troughs feeds into five

filters which operate under a suction of 20 in. of mercury, produced by three vacuum pumps. The caustic soda solution, now reduced in strength to only 2 per cent, is sucked out, and the cake is scraped off into a conveyor and discharged to the sewer.

The filtrate goes through two tanks and is pumped by seven 650-gal. Gould centrifugal pumps to eight filtrate storage tanks containing cooling coils. From these it is drawn to seven filtrate measuring tanks, from which it is returned to the autoclave. It is in this filter room that the caustic soda solution coming from the scrubbing towers in the liquid-air building is brought up to strength. It is then returned to the nitrogen department.

Nitric-Acid Department

The nitric-acid department comprises the catalyzer buildings, the oxidation towers and coolers, and the absorption towers for making nitric acid.

There are six catalyzer buildings, each 50 ft. x 210 ft., and each consisting of two units. On the west side of each catalyzer building there is a meter room. Under the meter room is a 5½-ft. air duct fed by blowers located in the first meter room. Ammonia gas is drawn

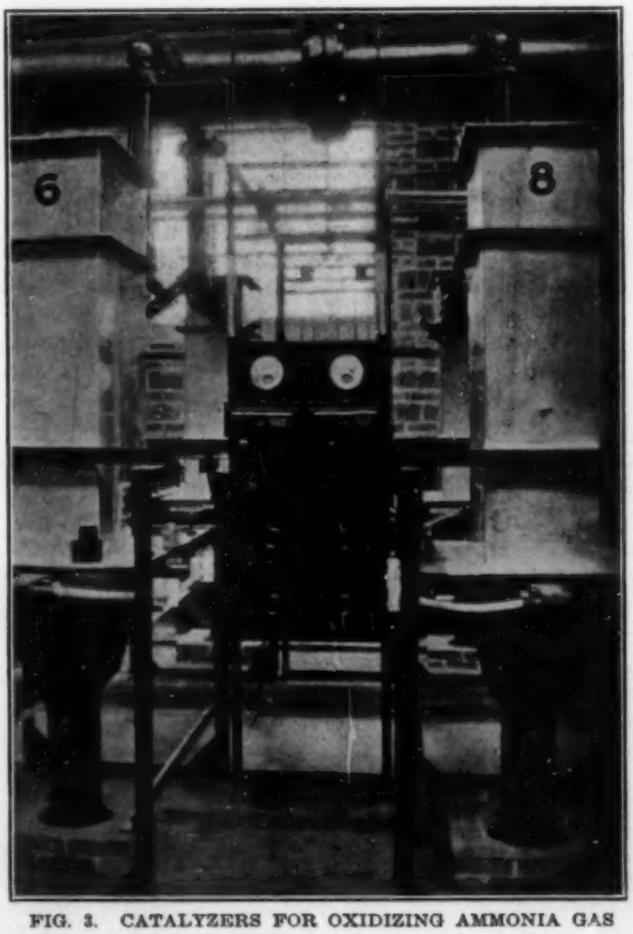


FIG. 3. CATALYZERS FOR OXIDIZING AMMONIA GAS

from the receiving tanks into which it was delivered from the ammonia-gas department, and by means of meters it is mixed with air in the proportion of 1:9 or 1:10. The mixture is passed into 12 steel mixing tanks (8 ft. in diameter x 30 ft. high) which are filled with 6-in. spiral rings. From the mixers the gas goes to the catalyzers.

In each catalyzer building there are four rows of catalyzers, 29 to a row, or 696 catalyzers in all. The photograph (Fig. 3) shows two catalyzers, with switchboard between, while Fig. 4 shows a row of catalyzers, with ammonia-feed pipe overhead and gas-discharge pipes leading out of the bottoms into a common flue. The catalyzers are spaced 5 ft. apart. The ammonia gas enters at the top through an iron pipe flanged to the aluminium casing, which is a rectangular box, 14 in. x 28 in. x 5 ft. high. At the base of the aluminium box there is a sheet of platinum gauze suspended in horizontal position. This gauze is made of $\frac{1}{1000}$ in. platinum wire, contains 80 meshes to the inch, and each sheet weighs 4.6 troy ounces. Each catalyzer has an 8-kw. transformer, and operates at 21 volts, stepped down from 460 volts, and 375 amperes. The platinum gauze is heated by the electric current to 750 deg. C. The ammonia gas, passing through the incandescent platinum gauze (which can be plainly seen through a small window in one side of the aluminium box) is converted into nitrogen oxides, and the converted gas escapes through a cast-iron pipe at the bottom of the catalyzer to a flue or tunnel made of concrete lined with chemical brick laid in acid-proof cement. These flues or tunnels convey the oxides of nitrogen to the oxidation towers and coolers.

The building for these towers and coolers is 100 ft. wide x 600 ft. long. There are 24 high-temperature coolers which are merely horizontal boilers supplied with steam at 25 lb. pressure. In these boilers the gas, passing through the boiler tubes, is cooled from 600 deg. to 200 deg. C. It then goes to 12 low-temperature coolers, through aluminium pipes 30 in. in diameter.

The low-temperature coolers consist of a rectangular chamber, divided into five compartments by four walls which do not reach entirely across the width of the chamber. The gas is thus caused to take a zigzag course through the chamber. Suspended from the top of the chamber are a large number of 5-in. tubes 7 ft. long—140 tubes to each of the five compartments. In two of the compartments the tubes are made of chemical stoneware, and in the three others of duriron, and each tube is provided with an outlet lip at the top. Inside each tube there is an inner tube, down which water flows. Escaping at the bottom of the inner tube, the water rises in the outer tube and escapes at the lip.

The gas is thus cooled to 30 deg. C. In these coolers nitric acid begins to form, and part of the nitric oxide becomes oxidized to nitrogen peroxide. The nitric acid formed is drained into No. 3 well of the absorption tower system. The gas, now a mixture of NO and NO_2, goes to the oxidation towers.

The Oxidation Tower

There are 12 oxidation towers, 15 ft. square, made of chemical brick. Each tower is divided by two walls into four equal compartments. The gas passes up one compartment, over the top of the dividing wall, down the next, through a hole at the bottom of the next wall, up the next compartment, over the wall, and down the last compartment. The gas is now practically all N_2O_4, and in this state passes on to the absorption towers.

The absorption-tower building (100 ft. wide x 600 ft. long) is located next to the oxidation towers, and to the

southeast of them. In this building there are twelve units of absorption towers, two towers to a unit connected in series. The structural steel for the towers is heavily coated with pitch, to protect it against corrosion. The towers, built of acid-proof brick laid in acid-proof cement, are 35 ft. square x 60 ft. high. Each tower is divided by interior brick walls into four compartments, as in the oxidation towers. The first tower of each unit is packed half way up with 6-in. spiral rings, and the upper half is packed with 3-in. spiral rings. The second tower of each unit is packed entirely with spiral

FIG. 4. VIEW IN CATALYZER BUILDING

rings of the 3-in. size. The gas from the oxidation towers passes into the first absorption tower of each unit, then into the second. In passing through the four compartments of each tower the gas pursues a course similar to that taken in the four compartments of the oxidation towers—up one compartment, down the next, and so on. Water is sprayed into the top of that compartment of the second towers of each unit last reached by the gas. From there on, the liquid pursues a course through the compartments of the two towers of each unit opposite to that taken by the gas, the liquid discharged from each compartment being used to feed to the top of the next forward compartment in the series. Thereby the liquid becomes progressively stronger in nitric acid as it passes from one compartment to another, until when it reaches the front compartment it has a strength of 50 per cent. The reactions in the absorption tower are expressed thus:

$$2NO_2 + H_2O = HNO_2 + HNO_3$$
$$HNO_2 + NO_2 = HNO_3 + NO$$
$$2NO + O_2 = 2NO_2$$

The pumping of the liquid is done by means of air lifts—a one-stage lift for each compartment of the 24 towers (96 in all) and 24 spares. To accommodate these lifts 120 wells, 12 in. in diameter and 100 ft. deep, were bored. The air lifts are made of 3-in. aluminium pipe, the lengths flanged together with duriron flanges. Air at 100 lb. is supplied to the air lift through a 1-in. pipe. The acid in that part of the air lift inside the well is cooled by water, constantly circulating into and out of the well. An electric signal system, connected to a signal lamp, will be provided for each well, for indicating any leakage of acid into the cooling water. On account of the low conductivity of pure water, the lamp will remain dark as long as there is no acid escaping, but the moment the least leakage occurs the acidulated water becomes a good conductor and the signal lamp becomes luminous.

The acid is pumped to the top of each compartment to a separator, where the air escapes. Then the acid goes to a distributor box, then to sprayers on the top of the tower.

Between the first and second towers of each unit there is an aluminium exhaust fan drawing the gas from the first tower and forcing it through the second. After the second tower of each unit there is another aluminium fan which discharges the residual gas into the atmosphere. The acid outlets for the towers are of 4-in. duriron pipe, flanged to the 3-in. aluminium air lift.

The final product of the towers is delivered to 12 aluminium weighing tanks (about 10 ft. in diameter and 12 ft. high) on scales, and is then discharged into 12 storage tanks, 25 ft. in diameter and 10 or 12 ft. high, made of concrete and lined with acid-proof brick. From the storage tanks the acid is drawn off by a 3-in. aluminium siphon to a 4-in. duriron header which conveys the acid to the next department.

The Nitrate Department

There are two branches of the nitrate department: (1) The neutralizing building, where the nitric acid is neutralized with ammonia gas, and (2) the crystallizing buildings.

In the neutralizing building (93 ft. wide x 150 ft. long) there are four absorbing towers with two mixing tanks, four condensers, four neutralizing tanks, four settling tanks, one receiving tank and three filter presses. There are also eight settling tanks located outside the building.

The nitric acid comes from the storage tank to the mixing tank, then by means of an air lift is elevated to the top of the absorbing towers. The latter are 7 ft. square x 20 ft. high, packed with 3-in. spiral rings. The unabsorbed ammonia gas from the neutralizing tank (see below) passes up these towers. From the bottom of the tower the liquid goes to the mixing tank; from this tank it is pumped to a distributing pot on top of the tower and from that it is drawn off to the neutralizing tank. The liquid still has an excess of nitric acid.

The Neutralizing Tank

In the neutralizing tank there are four 10-in. inlets for ammonia gas at the top. There is always about 3 ft. of liquid in the tank, so that the ends of the ammonia pipes, projecting through the top, are immersed in the liquid and the ammonia gas is forced to bubble through. The nitric acid is thus neutralized and ammonium nitrate, in solution, is formed. The reaction is:

$$HNO_3 + NH_3 = NH_4NO_3$$

The unabsorbed ammonia gas passes through a condenser which is like the low-temperature gas cooler for the gases leaving the catalyzers, only much smaller, then passes through the absorbing tower, where it meets nitric acid as previously described.

The ammonium nitrate solution goes from the neutralizer to storage tanks, then to the settling tanks. From time to time the sediment is taken out and put through the Sperry filter press. The filtrate goes to the filtrate tank and is re-treated. The final settling is done in eight ammonium nitrate tanks, where the liquor is stored for the next process—crystallization.

There are five ammonium nitrate or crystallizer buildings, each 60 ft. wide x 120 ft. long. They are all located 500 ft. apart and 500 ft. from any other building, as a precaution against explosion or fire. Being the scene of the last operation in the process, they are located at the southern extremity of the nitrate-plant site. Each building is supplied by a 6-in. pipe for ammonium nitrate solution, a 6-in. steam pipe, a 2½-in. compressed-air pipe, and a 2½-in. pipe for ammonia gas for completing neutralization in case the liquor should come up slightly acid.

Evaporating Pans

Each building has a storage tank for nitrate liquor (10 ft. in diameter x 12 ft. high) and ten evaporating pans, coated on the inside with a blue-enameled lining. These pans are 11 ft. long x 6½ ft. wide x 2¾ ft. deep. The pure nitrate solution is pumped to the crystallizer building, and from the storage tank there is drawn into the evaporating pans. The evaporation is accomplished by means of steam pipes. There are in each evaporating pan six 3-in. aluminium steam pipes, extending the full length of the pan and back again. Each evaporating pan is also equipped with three ½-in. air pipes, also of aluminium, which are used for agitating the liquid by means of compressed air, to facilitate evaporation. Over each pan there is a hood and flue for carrying away the fumes. Each pan is set up on six pedestals 2½ ft. high, so that the top edge of the pan is nearly 5 ft. from the floor, with ample air space underneath.

Each pan drains into two open-top crystallizing kettles, each 6 ft. in diameter x 2 ft. 2 in. deep, jacketed, and piped in such a way that they can be either steam-heated or water-cooled. They are also provided with an agitator, which revolves at the rate of 17 r.p.m.

The nitrate liquor is evaporated in the pan to the crystallizing point. It is then withdrawn at a temperature of 145 deg. C. from the pan to the kettle, where at first it is heated by means of steam in the jacket, so as to cool it gradually; then the steam is shut off and cooling water is admitted to the jacket while the agitator continues to revolve, and the ammonium nitrate crystallizes out in the kettle. A gate on the side of the kettle is opened and the agitator sweeps out the crystals on to a clean floor.

In appearance the ammonium nitrate is much like coarse-grained common salt. It is shoveled down through a hole to a lower floor, and is packed for shipment. The capacity of the five buildings is to be 300 tons of ammonium nitrate per day.

Water System

All water used in the chemical processes of this plant, as well as water for domestic and fire protection purposes, will be pumped from the main power house. For this purpose four 18-in. Allis-Chalmers centrifugal pumps, each with a capacity of 9730 gal. per minute, under a head of 200 ft., will be used. The water discharged from these pumps will be carried through two 36-in. cast-iron pipe lines running parallel from the power-house to the summit of the bluff to the south, about 3500 ft. away, thence through a 72-in. reinforced-concrete duct by gravity about 600 ft., into a settling and storage reservoir. This reservoir has a capacity of 60,000,000 gal., and has a settling area, when full, of 900,000 sq.ft. The water for the process may be taken direct from the reservoir through 36-in. reinforced-concrete pipe into cast-iron mains, or it may pass through the pumping station if more pressure is required. This station contains four 18-in., 9730-g.p.m. centrifugal pumps driven by 500-hp. motors, delivering into the process mains. The water for domestic purposes will be treated and filtered at the filtering plant just below the level of the reservoir and will discharge into the pumping station, where it will be handled by two 4-in. centrifugal pumps of 300-g.p.m. capacity each, driven by 25-hp. motors, and two 5-in. centrifugal pumps of 750-g.p.m. capacity, driven by 50-hp. motors. In this pumping station there will also be two 8-in. centrifugal fire pumps of 1500-g.p.m. capacity, each driven by a 100-hp. motor.

Long as the above description may seem, it does not by any means do justice to the plant. To cover adequately all the details of the process a volume could be written on each of the ten departments. This brief survey merely calls attention to the more important parts of the equipment and touches on the vital features of the process. It is difficult for any one who has not seen the plant to realize its magnitude—to grasp that there is at Muscle Shoals a huge plant of ten departments, any one constituting a large plant in itself, and the ten combined giving employment, when operating at full capacity, to between 3000 and 4000 men. The construction up to Nov. 15, 1918, and then incomplete, was said to have cost $60,000,000.

Built in Less Than a Year

The principal contractors for the plant have been: (1) The J. G. White Engineering Corporation, New York, in charge of power-house installation complete, bus-tunnel line and process-pipe lines (36 in.) for the water reservoir; (2) Westinghouse, Church, Kerr & Co., New York, in charge of erection of plant buildings, etc.; and (3) Chemical Construction Co., responsible for the construction and installation of much of the chemical equipment, such as towers and their accessories, coolers, gas flues, tanks, etc.

On Nov. 25, 1918, individual units were operating in every building as far as the lime-nitrogen-mill building, the product having reached that point on its way through the process. Units in all the other departments were being tuned up and dried out. The power in use, only 5000 kw., was being delivered to the plant by the Alabama Power Co. It was expected that by the latter part of December the plant would be operating at the rate of 30,000 kw. (33⅓ per cent capacity); by Jan. 1, 1919, at the rate of 50,000 kw. (45 per cent capacity); and by Feb. 1, at the rate of 90,000 kw., or full capacity. If this schedule is adhered to, the plant will be in full operation in less than one year from the date of first breaking ground.

Exhaust Steam at High Back Pressures

A System of Charts Based on Thermodynamical Formulae and Data with Reference to Boiler Pressures and Cutoffs—Description of an Eight-Ton Dye Plant Operation Using Steam Jacketed Evaporating Pans, Vacuum Driers, Kettles and Chambers

BY CROSBY FIELD

STEAM as exhausted from an engine contains approximately 85 per cent of the amount of heat contained in the steam supplied to the engine. This fact has long been recognized and attempts have been made to utilize exhaust steam for many industrial purposes, but due to the high temperatures used in the dyestuff and other similar chemical industries full value of the exhaust steam has not been attained therein.

The object of this paper is to provide a set of charts from which the plant engineer can very rapidly determine just what back pressure would be the economical one for him to use provided the chemical processes involved do not require a higher temperature than that provided by this back pressure. A method is also suggested whereby the plant engineer may use some of this exhaust steam when the process requires a temperature too great for exhaust steam at the economical pressure.

The pressures to which exhaust steam can economically be carried are very much higher than is usually thought. For several years past the writer has very successfully used back pressure at 50 lb. per sq.in. gage and under some conditions has used 80 lb. per sq.in. gage. This is accomplished with absolutely no deleterious effect upon the machinery.

It is not to be assumed that the writer believes that high back pressures are universal panacea, but he does believe that they should be used much more than they have been in the past.

EXPLANATION OF CHARTS

Instead of dealing with these subjects theoretically and including a large number of interesting formulæ, which the plant engineer will probably never have the time to investigate, the accompanying charts used by the writer in his practice are given, and in addition examples of their use. In referring to these it must be remembered that:

They are all based on the theoretical expansion curve of steam, i. e.,

$$P_m = p_i \frac{1 + \text{hyp. log. } R}{R}$$

or $P_m = P_f\ (1 + \text{hyp. log. } R)$

wherein

P_m = absolute mean pressure

p_i = absolute initial pressure considered uniform up to cutoff

P_f = the terminal pressure

R = ratio of expansion.

They are not offered as accurate scientific work, but merely as being charts found of value to the writer and of sufficient accuracy to warrant their continued use. It is believed that these approximate all of the commercial cutoffs. It must be remembered that they are purely theoretical curves and give an approximation only of actual conditions. It is believed, however, that in most cases these curves will solve the problem to an accuracy of from 5 to 10 per cent, which is sufficiently close for the plant engineer, as the inaccuracy due to the differences of operation at various times will usually more than offset this.

On both the sets of curves from Figs. 2 to 12 inclusive, an additional scale has been run giving the theoretical increase in the weight of steam used for the same power due to the increased back pressure, so that all needed quantities can be read off of the chart at once. Fig. 13 is necessary when it is desired to solve complicated cases which cannot be readily solved by a single reading of the previous charts.

EXAMPLES—USING CHARTS

For illustration, assume a color plant producing 500,000 lb. total of several colors per month, containing the following chemical apparatus:

20 Evaporating pans,
10 Vacuum driers,
20 Jacketed cooking kettles,
5 Air blast dry rooms,
Large number of tubes containing materials boiled by injection of live steam through pipes, etc.

Upon closer investigation, the following summary presents itself:

SAMPLE SUMMARY SHEET OF STEAM CONSUMPTION IN DYESTUFF PLANT

Item	Apparatus	Number	Temp. of Product Deg. F.	At Present Supplied by	Remarks
1	Evaporating pans	15	214	Boiler steam through reduction valve to 35 lb.	This pressure is as high as can be used satisfactorily in order to prevent boiling over.
2	Evaporating pans	5	214	Boiler steam through reduction valve to 5 lb.	
3	Vacuum driers	5	?	Boiler steam through reduction valve to 3 lb.	This pressure cannot be raised due to danger of burning product
4	Vacuum driers	5	?	Boiler steam through reduction valve to 40 lb.	
5	Cooking kettles	10	230	Boiler steam through reduction valve to 80 lb.	
6	Cooking kettles	5	240	Boiler pressure	
7	Cooking kettles	5	260	70 lb.	
8	Air blast dry room	5	100 to 180	Boiler pressure	

The above apparatus consumes an average of 50,000 lb. of steam per hour and 700 kw.-hrs. per hour. Assuming this latter equivalent to 29,000 lb. (see below), the total steam required is 79,000 lb. per hour.

Item 1 can be operated on a pressure of 35 lb. or over, item 2 on a pressure of 5 lb. or over, item 3 on a pressure of 3 lb. or over, item 4 on a pressure of 40 lb. or over, item 5 on a pressure of 40 lb., by adding addi-

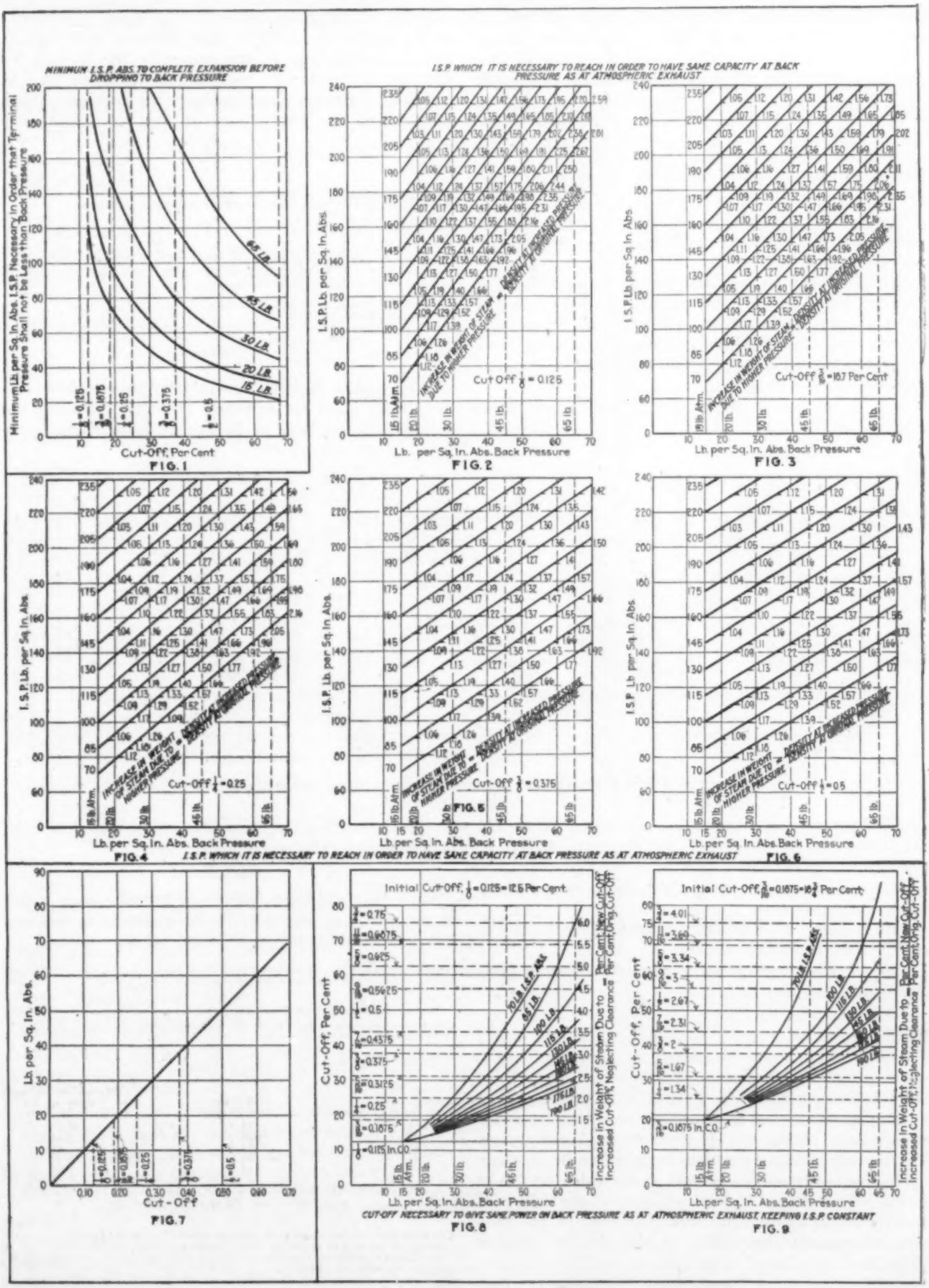

MINIMUM I.S.P. ABS. TO COMPLETE EXPANSION BEFORE DROPPING TO BACK PRESSURE
Minimum I.S.P. Abs. Necessary in Order that Terminal Pressure Shall not be Less than Back Pressure
Cut-Off, Per Cent
65 LB.
45 LB.
30 LB.
20 LB.
15 LB.
I.S.P. WHICH IT IS NECESSARY TO REACH IN ORDER TO HAVE SAME CAPACITY AT BACK PRESSURE AS AT ATMOSPHERIC EXHAUST
I.S.P. Lb. per Sq. In. Abs.
Lb. per Sq. In. Abs. Back Pressure
INCREASE IN WEIGHT OF STEAM DUE TO HIGHER PRESSURE = DENSITY AT INCREASED PRESSURE − DENSITY AT ORIGINAL PRESSURE
Cut-Off = 0.125
Cut-Off = 0.1675 Per Cent
Cut-Off = 0.25
Cut-Off = 0.375
Cut-Off = 0.5
15 lb. Atm.
20 lb.
30 lb.
45 lb.
65 lb.
Lb. per Sq. In. Abs.
Cut - Off
Initial Cut-Off, = 0.125 = 12.5 Per Cent.
Initial Cut-Off, = 0.1675 = 16¾ Per Cent.
Cut-Off, Per Cent
Lb. per Sq. In. Abs. Back Pressure
Increase in Weight of Steam Due to Increased Cut-Off, Neglecting Clearance = Per Cent. New Cut-Off / Per Cent. Orig. Cut-Off
Increase in Weight of Steam Due to Increased Cut-Off, Neglecting Clearance = Per Cent. New Cut-Off / Per Cent. Orig. Cut-Off
65 LB. I.S.P. ABS.
80 LB.
100 LB.
115 LB.
130 LB.
145 LB.
160 LB.
176 LB.
190 LB.
0.125 In. C.O.
0.1675 In. C.O.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

FIG. 6

I.S.P. WHICH IT IS NECESSARY TO REACH IN ORDER TO HAVE SAME CAPACITY AT BACK PRESSURE AS AT ATMOSPHERIC EXHAUST

FIG. 7

FIG. 8

FIG. 9

CUT-OFF NECESSARY TO GIVE SAME POWER ON BACK PRESSURE AS AT ATMOSPHERIC EXHAUST, KEEPING I.S.P. CONSTANT

tional heating surface in form of coils to an amount as given by the formula

$$\frac{Ts \text{ at } 80 \text{ lb.} - T_P}{Ts \text{ at } 40 \text{ lb.} - T_P} - 1 = \frac{324 - 230}{287 - 230} - 1 = 65 \text{ per cent}$$

where Ts represents the temperature of steam and T_P the temperature of product.

Item 6 can be operated on a pressure of 40 lb. by adding additional heating surface in form of coils equal to:

$$\left(\frac{Ts \text{ at boiler pressure} - 240}{Ts \text{ at new back pressure} - 240} - 1\right) \times 100 = \text{per cent}$$

more.

Item 7 cannot be operated on any reasonable back pressure, hence a special line must be run here from the boiler pressure service mains. A test made by measuring the drip discharges from these apparatuses, however, gives a total value of steam consumed this way of only 3000 lb. per hour.

Item 8 can be run on 40 lb. by adding additional heating surface.

From Fig. 4 the necessary initial steam pressure to give same power on 65 lb. back pressure as on 105 lb. absolute exhausting to atmosphere is 185 lb. and the increase in weight of steam is 1.7. This can also be calculated from the steam tables, when increased steam weight will be proportional to increase of density $\left(\frac{4.24}{2.48} = 1.7\right)$.

Steam supplied engines at 185 lb. = 29,000 × 1.7	49,300
Steam condensed by expansion (Fig. 14), (Molier chart), (100 per cent — 93 per cent)	7 per cent.
Condensation losses	6 per cent
Total losses	13 per cent
Steam returned to factory by engines at 65 lb., 49,300 × (100 per cent — 13 per cent)	43,000
Steam required by factory at 65 lb	47,000
Deficit to be made up by reduction value	4,000
Required by factory at 185 lb	3,000
Total steam supplied by boilers at 185 lb., 49,300 + 4,000 + 3,000	56,300

Per cent saved, $\frac{79{,}000 - 56{,}300}{79{,}000} = 29$ per cent

This permits shutting down the 20 per cent low pressure boiler plant for economy. Thus by increasing the pressure on one bank of boilers we have succeeded in wholly eliminating the use of the other, thanks to high back pressure exhaust.

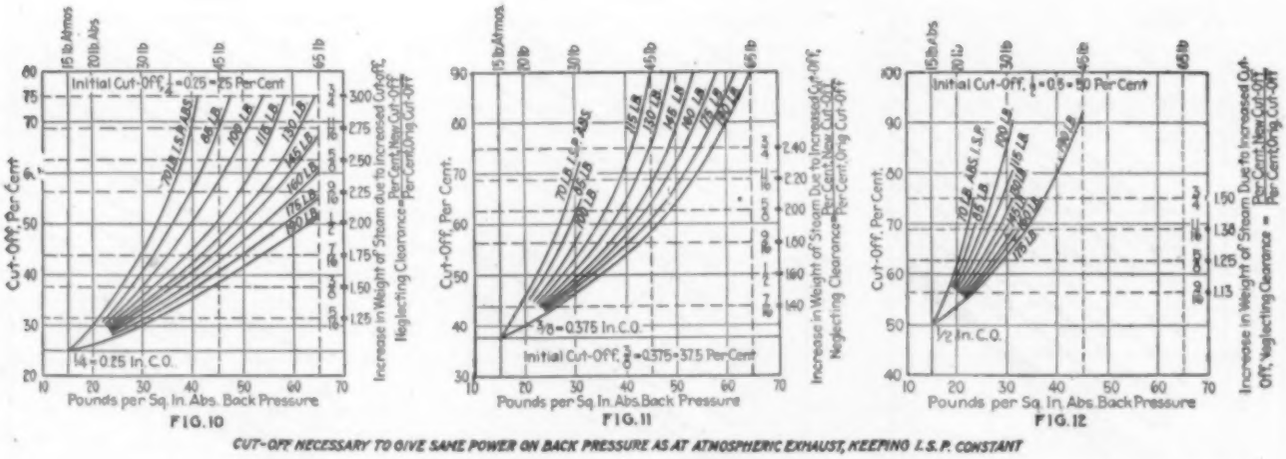

Cut-Off, Per Cent.
Pounds per Sq. In. Abs. Back Pressure
Increase in Weight of Steam due to Increased Cut-Off, Neglecting Clearance = Per Cent. New Cut-Off / Per Cent. Orig. Cut-Off
Initial Cut-Off, 1/4 = 0.25 = 25 Per Cent
1/4 = 0.25 In. C.O.
Initial Cut-Off, 3/8 = 0.375 = 37.5 Per Cent
3/8 = 0.375 In. C.O.
Initial Cut-Off, 1/2 = 0.5 = 50 Per Cent
1/2 In. C.O.

FIG. 10 FIG. 11 FIG. 12

CUT-OFF NECESSARY TO GIVE SAME POWER ON BACK PRESSURE AS AT ATMOSPHERIC EXHAUST, KEEPING I. S. P. CONSTANT

In order to illustrate the various use of the charts and calculations, three different conditions of the power plant will be assumed:

Case A—High back pressure obtainable by increasing initial steam pressure.

Case B—High back pressure obtainable by increasing cutoff of reciprocating engines.

Case C—High back pressure obtainable only by combination of the above.

Case A

High back pressure obtainable by increasing initial steam pressure: Assume a plant in which one-fifth of the total horsepower consists of H.R.T. boilers having a safe pressure of 100 lb. gage and the balance of water tube boilers having a safe pressure of 175 lb. gage. The average working pressure is therefore 90 lb. gage.

This case is typical of several plants which started to install high pressure boilers, but due to long deliveries and too rapid increase in production had to purchase something quickly, hence filled in with the low pressure H.R.T.'s.

Boiler pressure 400 kw. of Corliss engines at 35 lb./kw.-hr.	14,000
300 kw. slide valve engines at 50 lb./kw.-hr.	15,000
Hourly steam demand at atmospheric exhaust	29,000

Cut off from indicator cards = ¼.

Case B

High back pressure obtainable by increasing cutoff of reciprocating engines: Boiler pressure on engines, 130 lb. Allowable boiler pressure, 140 lb.

Plant averages 400 kw. of Corliss engines at 35 lb. per kw.-hr	14,000
300 kw. of slide valve engines at 50 lb. steam per kw.-hr	15,000
Total average hourly steam demand for power	29,000

Cutoff from indicator cards = ¼ (0.187 = 18.7 per cent)
130 lb. gage = 145 lb. absolute.

From Fig. 9:

Absolute Back Pressure, Lb. per Sq. In.	Cutoff for Same Power	Approximate Increase in Weight of Steam for Same Power
15	18.7	0.00
30	26.0	1.46
45	35.0	1.80
55	43.0	2.20
65	49.0	2.60

APPROXIMATE HIGHEST BACK PRESSURE TO UTILIZE ALL OF THE EXHAUST STEAM

	Per Cent.
Average expansion loss (equals moisture in steam at exhaust pressure, assuming dry and saturated at initial pressure can be read directly from Molier diagram, Fig. 14)	6
Average condensation losses	6
Total	12
Allow	3
Total	15

Steam consumption of factory which might be used on low pressure (15 to 65 lb.) = 50,000 — 3,000 = 47,000.

Steam consumption of engines = 29,000.

Proportion factory to engine consumption = $\frac{47,000}{29,000}$ = 1.62.

Adding 15 per cent for losses, factor becomes 1.62 × 1.15 = 1.87.

Most Economical Back Pressure

From Fig. 9 we see that the most economical back pressure is at the point of intersection of the ratio, value of 1.87 with the curve for 145 lb. = 45 lb. absolute back pressure (= 30 lb. gage) and 35 per cent cutoff. If sufficient additional heating surface can be put in the chemical apparatus to compensate for this reduced steam pressure, the problem is solved, the saving being approximated as follows:

Steam supplied to engines at 145 lb., 29,000 × 1.87	53,400
Loss due to expansion (Molier diagram, Fig. 14), (100 per cent — 92 per cent)	8 per cent
Loss due to condensation	6 per cent
Total loss	14 per cent
Steam supplied by engines to factory at 45 lb., 53,400 × (100 per cent — 14 per cent)	47,000
Steam demanded by factory at 45 lb., 50,000 — 3,000	47,000
Total steam supplied engines by boilers at boiler pressure	53,400
Total steam supplied factory by boilers for item 7	3,000
Total steam supplied factory by boilers under new conditions	56,400
Total steam supplied factory under original conditions	79,000
Saving	22,600
Per cent saving, $\frac{22,600}{79,000}$ = 28.6 per cent	
Steam now chargeable to power, 53,400 × 14 per cent	7,400
Steam formerly chargeable to power	29,000
Saving	21,600
Per cent saving, $\frac{21,600}{29,000}$ = 74½ per cent	

The method of attack when back pressure as found above is too low for the factory demands will be described below. Let us now examine the question of what pressure is necessary for the factory.

This is usually fixed by the highest temperature of product. The best way to proceed is to ascertain both by inquiries from the chemist and plant foreman and personal investigation just what is the highest temperature at which the products must be maintained. Also note whether the kettles are connected to a high or low pressure main and what is the average steam pressure at the jacket. Although the temperature drop and the heat transmission have been thoroughly investigated theoretically, yet the various differences in condition of heating surfaces and nature of materials renders proper application of the theoretical results difficult. The writer is doing a considerable amount of research on this point and may have results to publish later. For the present he has found a 50 deg. F. temperature drop to be sufficient in almost every case. Consequently the highest temperature of the product plus 50 deg. will give the temperature of the steam required in the jacket from which the necessary back pressure may be established. Having established this, the question of sizes of pipe and general steam calculations become easy.

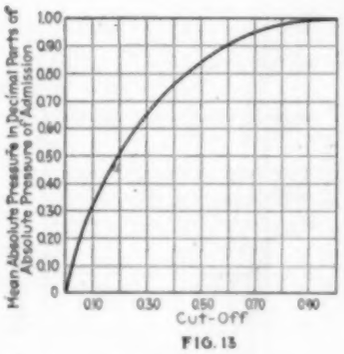


FIG. 13

STEAM ENGINE RATIOS

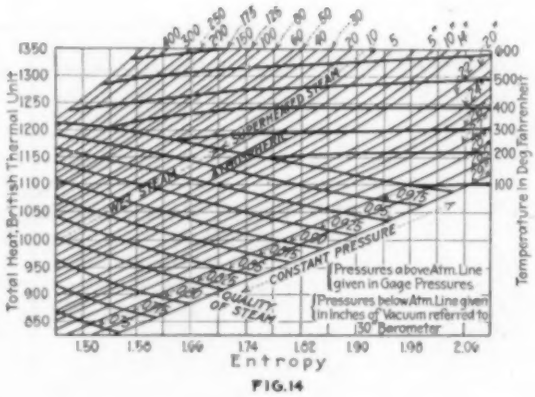

Total Heat, British Thermal Units
Temperature in Deg. Fahrenheit
Entropy
SUPERHEATED STEAM
WET STEAM
CONSTANT PRESSURE
QUALITY OF STEAM
Pressures above Atm. Line given in Gage Pressures
Pressures below Atm. Line given in Inches of Vacuum referred to 30" Barometer

FIG. 14

MOLIER DIAGRAM

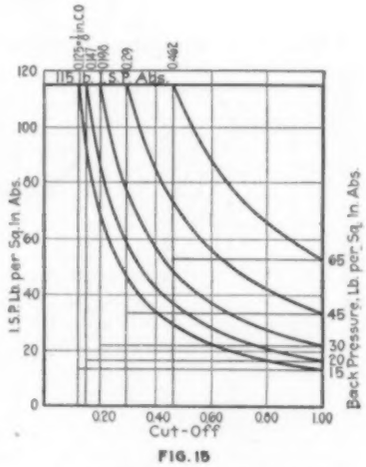


FIG. 15

EXPANSION CURVES SAME POWER AND I. S. P.

In special cases the value of the back pressure necessary may be determined by the economical pressure for the design of evaporating and cooking apparatus. Remembering that the rate of evaporating varies proportionately with the temperature differences and noting from the following table:

Pounds per Inches Abs.	Steam Temp., Deg. F.	Temp. Drop	B.t.u.'s per Sq.Ft. per Hour	Lb. Water Evaporated per Hour
15	212	0	0	0
20	228	16	8,000	8.4
30	250	38	19,000	19.6
45	275	63	32,000	33.0
65	298	86	43,000	44.5
70	303	91	.....	...
85	316	104	.....	...
100	328	114	.....	...
115	338	126	.....	...
130	347	135	.....	...
145	356	144	.....	...

We see, if we assume the case under consideration to be that of evaporating in an open vessel, that at a 50-lb. back pressure a given apparatus would do more than five times the work it would do at a 5-lb. back pressure, and similarly that a 50-lb. back pressure and a given apparatus would do about 70 per cent of the work it would do at a 100-lb. pressure.

The matter of the coefficient of heat transmission is a matter of conjecture varying greatly with the different conditions of evaporation. Theoretically the coefficient of heat transmission for iron is 233 B.t.u.'s per square foot per hour per degree temperature difference per inch in thickness. As evaporating and cooking apparatus is rarely over ¼-in. thick, this will give us approximately 900 B.t.u.'s per square foot per hour per Fahrenheit degree difference of temperature. Because

of the above variable conditions a good all around average value is 500 B.t.u.'s per square foot per hour per degree difference of temperature. This coefficient for heat transmission does vary greatly with pressure, according to Kerr in his article in the July, 1916, issue of the *Journal of the American Society of Mechanical Engineers*, page 545:

"Let V = coefficient of heat transmission in B.t.u.'s per square foot per hour per degree Fahrenheit, and let D = density of the heating steam in pounds per cubic feet, then: $V = 225 + 17{,}500\ D$."

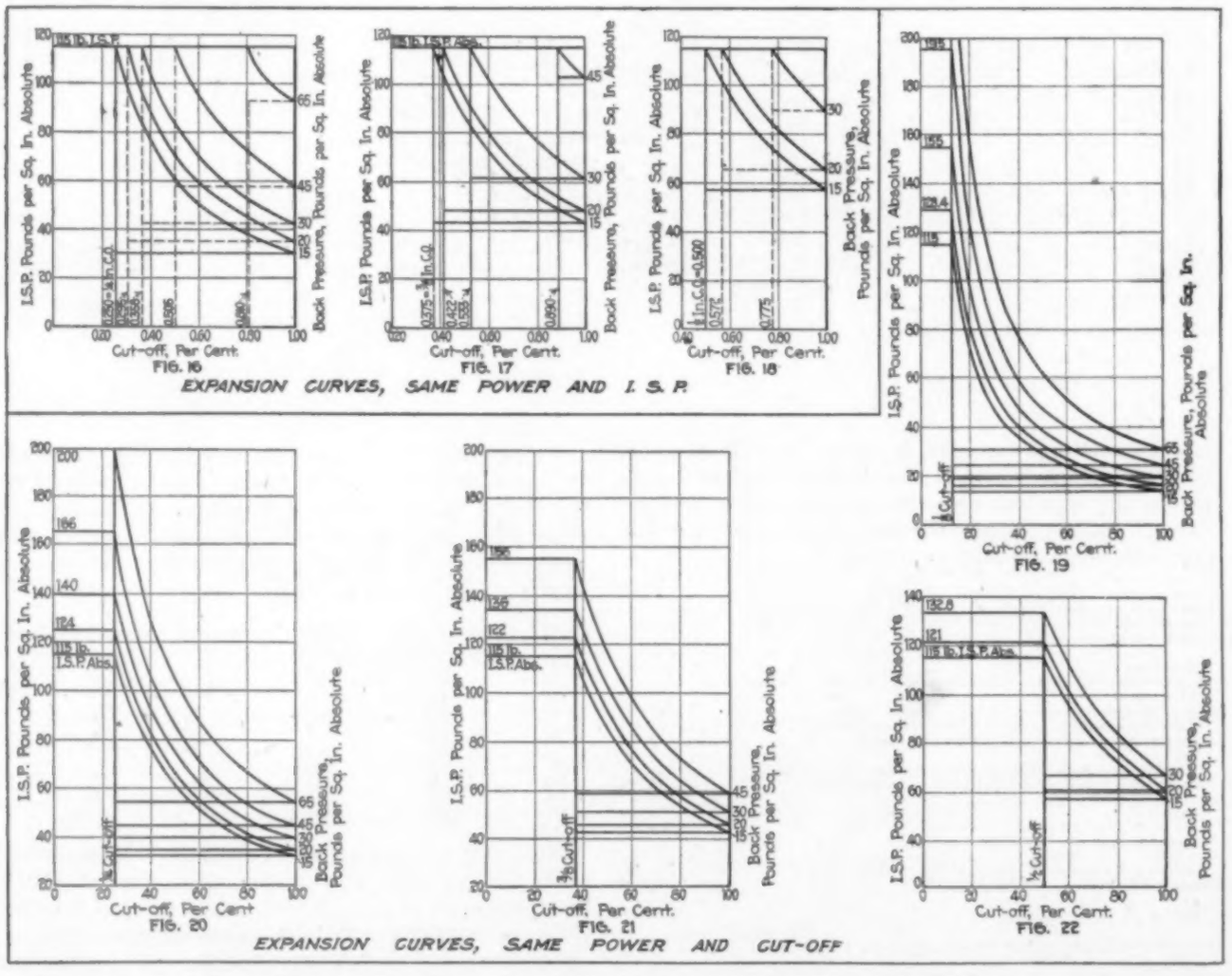
On the other hand, in a writers' discussion by Dr. Orrok, comparison was made with Parr's formulæ, where

$$V = 1290\sqrt{PD}$$

where P = absolute pressure in lb. per sq.in.

scale of Fig. 9, but may be calculated as follows: Assuming 65 lb. back pressure and 49 per cent cutoff we get the increase in weight of steam by engines = $\frac{49}{18.7}$ = 2.6

Hourly steam demand for power at 65 lb., 29,000 × 2.6	76,000
1 lb. steam expanding from 145 to 65 lb. will be (Molier diag. Fig. 14), 94 per cent dry at latter pressure	
Loss due to moisture (expansion), 100 — 94 per cent	6 per cent
Assuming 6 per cent condensation loss	6 per cent
Total loss	12 per cent
Steam supplied by engines at 65 lb. to factory, 76,000 × (100 per cent — 12 per cent)	67,000
Steam required by factory at 65 lb	47,000
Excess steam supplied at 65 lb	20,000
Total steam under atmospheric conditions—power	29,000
Total steam under atmospheric conditions—factory	50,000
Total steam under atmospheric conditions, power-factory	79,000
Total steam under 65 lb. back pressure conditions, power-factory	76,000
Total steam factory at boiler pressure	3,000
Total steam from boiler under 65 lb. back pressure conditions	79,000



Even with the lowest values by these formulæ, steam at 8-lb. gage pressure gives a coefficient V = 1200, which is too high and never reached in practice. The writer uses 500.

Method of Attack When Economical Back Pressure Cannot Be Used Because of Factory Conditions of Temperature

Assume a back pressure of 65 lb. absolute (equals 50 lb. gage) necessary for temperature conditions. The increase in steam will be approximately directly as the increase in cutoff. This is given as the ratio ordinate

Evidently for these conditions the gain is 20,000 lb. of steam for heating feed water at 65-lb. back pressure or for additional production, which in many ways would be well worth while. This system provides great capacity for heavy factory steam demand, as it could be said that there were 20,000 lb. of steam each hour which could be automatically diverted to the feed water heater or into the factory. It might be better, however, to run half the Corliss engine units (200 kw.) on an atmospheric feed water heater. The calculations then become:

200 kw. Corliss engines at 35 lb. kw.-hr.	7,000
300 kw. slide valve engines at 50 × 2.6	39,000
200 kw. Corliss engines at 35 × 2.6	18,200
Steam supplied to engines at 145 lb.	64,200
Steam delivered by engines to factory at 65 lb., (39,000 + 18,200) × 0.88	50,300
Steam required by factory at 65 lb.	47,000
Excess for feed water heating and balance	3,300
Steam supplied engines	64,200
Steam supplied factory, at 145 lb.	3,000
	67,200

Saving of this system, $\frac{79{,}000 - 67{,}200}{79{,}000}$ = 15 per cent + 3,300 lb. for feed-water heating.

Amount chargeable to power, crediting power with 65 lb. feed water = 64,200 — (39,200 + 18,000) × 0.88 = 13,900.

Percentage of former amount $\frac{13{,}900}{29{,}000}$ = 48 per cent.

Amount chargeable to power, not crediting power with 65 lb. feed water = 64,200 — 47,000 = 17,200

Percentage of former amount, $\frac{17{,}200}{29{,}000}$ = 59 per cent.

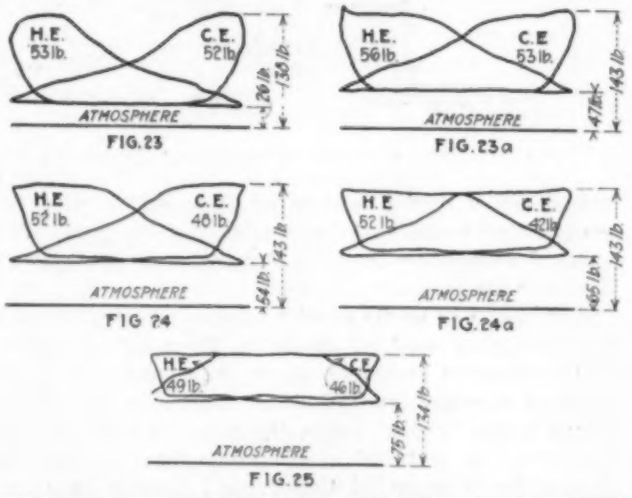
Case C

High back pressure obtainable only by combination of increased initial steam pressure and longer cutoff:

Working boiler pressure, 115 lb. gage equals 130 lb. abs.

Allowable boiler pressure, 150 lb. gage equals 165 lb. abs.

For same capacity and engine cutoff of ¼, from Fig. 4 the allowable back pressure will be increased from 15 lb.



FIGS. 23 TO 25. SOME SAMPLE INDICATOR CARDS TAKEN FROM AN ENGINE WORKING UNDER USUAL CHEMICAL PLANT NEGLECTFUL CONDITIONS, BUT WELL ILLUSTRATING THE ACTION AT VARYING BACK PRESSURES (FIGURES WITHIN THE DIAGRAMS ARE MEAN EFFECTIVE PRESSURES)

absolute to 33 lb. absolute by increasing the boiler pressure from 130 to 160 abs.

Ratio, $\frac{\text{Mean Absolute Pressure}}{\text{Initial Steam Pressure}}$ for 25 per cent cutoff = 0.586 (Fig. 13).

Mean absolute pressure = 160 × .586 = 93.8.

New back pressure (absolute) = 65 lb.

New mean absolute pressure = 93.8 + (65 — 33) = 125.8.

$$\text{New ratio} = \frac{125.8}{160} = 0.785$$

New cutoff (Fig. 13) = 43 per cent.

Weight of steam per hp. will increase as its density, hence at 160 lb. will be $\frac{3.46}{2.84}$ = 1.22 times its weight at 130 lb. It will also increase directly as the percentage cutoff (neglecting clearance), hence at 43 per cent cutoff will be $\frac{43}{25}$ = 1.72 times its weight at 25 per cent cutoff. The total increase in weight of steam therefore will be 1.72 × 1.22 = 2.10. This value is high, because of the assumption made.

One lb. of steam expanding from 160 to 65 will be 94 per cent dry (Molier chart, Fig. 19) at the latter pressure. Allow a value of 6 per cent for cylinder condensation and leakage losses, and we have:

Total steam delivered by boilers to engines at 160 lb. pressure, 2.1 × 29,000	60,800
Total steam delivered by engines to plant at 65 lb., 2.1 × (0.94 — 0.06) × 29,000	53,500
Steam chargeable to power	7,300

Percentage of steam formerly used for power, $\frac{7{,}300}{29{,}000}$ = 25 per cent

Total steam required by factory at 65 lb., 50,000 — 3,000	47,000
Total steam delivered by engines at 65 lb.	53,500
Excess steam for feed water heating at 65 lb.	6,500
Steam required by factory at boiler pressure for item 7 (115 lb. gage—atmospheric)	3,000
Total steam under old conditions, 50,000 + 29,000	79,000
Total steam under new conditions (145 lb. gage to 50 lb. gage), 60,800 + 3,000	63,800
Saving in total steam, new as compared to old conditions	16,200

Per cent saving, $\frac{16{,}200}{79{,}000}$ = 21 per cent

Other Savings

When electricity is bought the substitution of cheap slide valve engines will often show a remarkable saving, when all the exhaust steam can be utilized in one of the ways shown above. For example, assume electricity at 2 cents per kw.-hr. and steam at 25 cents per 1000 lb.: Steam per kw.-hr. through engine, 50 × 1.75 = 87.5 lb. Steam used for power per kw.-hr., 87.5 × 0.12 = 10.5 lb.

Cost of steam per kw.-hr., $\frac{25 \times 10.5}{1000}$ = 0.262 of 1 cent.

Saving in power bill, $1 - \frac{0.262}{2000}$ = 87 per cent, which must be decreased by wages of engine room force, oil and supplies and interest and depreciation on engines (but engine room alone—*not* boilers).

Fifty pounds is sufficient pressure to run steam-driven duplex pumps under average conditions met in chemical plants. Where this does not result in sufficient pressure, a cheap remedy is to introduce liners in the liquid cylinders of the pump.

Superheat—Theoretically the ideal superheat to use is just sufficient to provide dry and saturated steam after expansion in the engines. Usually this means a total temperature of 550 deg. F. to 600 deg. F. As the average chemical plant is not operating with superheat to-day, no example is here given, but same can be readily solved by means of the charts.

Additional Cost of Increased Pressure

In some of the above examples the solution involves a slight increase of boiler pressure. Although theoretically this implies a corresponding increase in coal burned, yet experience has shown that this factor, if present, is so negligible as to be indistinguishable. In other words, no more coal is burned, in testing under normal plant conditions, to deliver one pound of steam at the higher pressure than at the lower, within the limits above indicated.

In 1915 one of the writer's plants was confronted with the following problem:

Three 200-hp. H. R. T. boilers good for a maximum

pressure of 150 lb. gage were supplying the factory. Due to the large amount of steam required, they were unable to maintain the pressure of 125 lb. The factory pressure was normally between 60 and 90 lb. It was also supplied with 150-hp. boilers, good for a maximum pressure of 90 lb. gage. The proposal was made to combine these with the H. R. T. boilers and run in that unsatisfactory way at about 85 lb. gage.

Instead of this a back pressure of 40 lb. per sq.in. gage was decided upon and the three high pressure H. R. T. boilers were operated at a pressure of about 140 lb. The 90-lb. boilers were used when necessary to make up for extra load through a reduction valve to bleed low pressure steam into these 40 lb. back pressure mains. Since that time the load on the boilers has been increased nearly three times, and although hand fired the high pressure mains vary between 125 and 140 lb., averaging 135 lb., and the low pressure mains are held practically constant at 40 lb. The result has been a great economy of fuel, ability to operate not only when lack of boiler capacity apparently prevented operation, but also after a considerable increase in the chemical apparatus load. A saving of many thousands of dollars has been accomplished.

SUMMARY

The charts show very clearly the great advantages of having as high as possible initial steam pressure, and furthermore indicate the way to increase the present steam pressure by adding higher pressure units gradually, retaining the lower pressure to assist the back pressure exhaust system.

The higher the initial steam pressure the higher back pressure may be, with smaller pipes and less cost for installation of both. A comparison of pipe sizes is given below:

COMPARISON OF PIPE SIZES

40 lb. gage back pressure requires a pipe	7.82 / 23.80	or 32.9 per cent. of pipe required	for 2 lb.
40 lb. gage back pressure requires a pipe	7.82 / 19.45	or 40.2 per cent of pipe required	for 6 lb.
40 lb. gage back pressure requires a pipe	7.82 / 3.89	or 203 per cent of pipe required	for 100 lb.
40 lb. gage back pressure requires a pipe	7.82 / 3.12	or 251 per cent of pipe required for	130 lb.
40 lb. gage back pressure requires a pipe	7.82 / 2.84	or 277 per cent of pipe required for	145 lb.
50 lb. gage back pressure requires a pipe	6.68 / 23.80	or 28 per cent of pipe required	for 2 lb.
50 lb. gage back pressure requires a pipe	6.68 / 19.45	or 24.3 per cent of pipe required	for 6 lb.
50 lb. gage back pressure requires a pipe	6.68 / 3.89	or 172 per cent of pipe required for	100 lb.
50 lb. gage back pressure requires a pipe	6.68 / 3.12	or 214 per cent of pipe required for	130 lb.
50 lb. gage back pressure requires a pipe	6.68 / 2.84	or 235 per cent of pipe required for	145 lb.

The utility of high-pressure exhaust steam is evident. In general, wherever the factory use of steam is approximately equal to the power use, low pressure exhaust steam should be used. A factory use of steam of about double the power use or greater will usually justify the highest pressure exhaust steam. Between these limits the economical back pressure will vary as explained above. Because of the many different conditions to be found, further summarization has not yet been thought advisable in this paper, intended only to explain the accompanying charts, as in using them the reader will naturally form his own conclusions.

In so far as this type of chemical plant is concerned, the writer believes the ideal condition of operation is as given in Fig. 26. This assumes that the highest pressure required for the factory processes is 65 lb. absolute, which the writer has found to be true in his plants so far. In those chemical plants where a higher pressure is required, it will be necessary to modify Fig. 26 accordingly.

The steam is generated at a pressure of from 200 to 300 lb., and because of the usual operating conditions the boiler house is a considerable distance from the center of the steam load. Transmission of steam is through a comparatively small pipe, utilizing high velocities. A reduction valve at the receiving end permits rapid and large fluctuations of the steam pressure at the boiler, without affecting the pressure at the engines. These fluctuations may be due to irregularities in firing

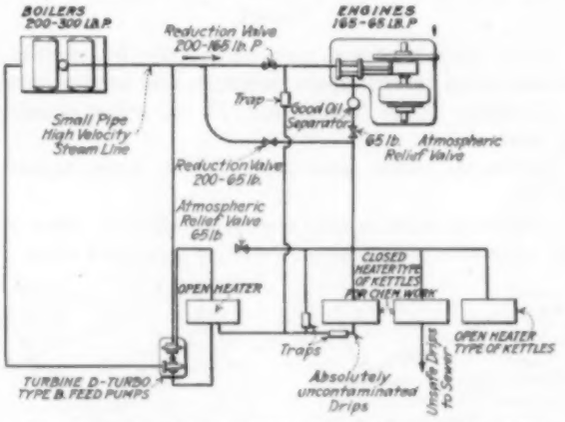


FIG. 26. STEAM LAYOUT FOR CHEMICAL PLANT

and to sudden fluctuations in the demand; the latter are exaggerated because of the smallness of the pipe. This valve, furthermore, tends to dry the steam just before it enters the engines.

The engine exhausts at 65 lb. absolute, and after passing through a good oil separator, the steam is carried to the chemical processes, where it is consumed in one of three principal types of steam consumers. In one, the closed heater type of kettle, the steam is never in contact with the material in the kettle, nor is there any danger to be expected therefrom. Usually this is a heater in which the chemical is never under pressure. The second type is also a closed heater, but as the pressure of the chemical may at some time or other be greater than the pressure of the steam, the drips must be considered unsafe, and either wasted to the sewer or utilized in some other way wherein there is no danger of contaminating the boilers. The third type is the open heater type, in which the steam is actually made a part of the liquid it heats. A closed type boiler feed water heater is also included in both sketch and above description as part of type one, in order to balance any excess steam at 65 lb. Under certain conditions it would be advantageous to use some type three heaters as the supply for boiler feed pumps.

The remainder of the system is evident. It is to be noted, however, that because of the two atmospheric relief valves and two reduction valves, steam pressures must remain practically constant on both the initial and the exhaust steam side of the engines, regardless of the conditions of steam production or of steam consumption.

Influence of Gypsum on the Blast Furnace Slags in the Manufacture of Cement

A Report on the Granulated Slag-Lime-Gypsum Composition Cements as Developed In Russia—Resistance to SO Ion Has Demonstrated Value In Construction Subjected to Sulphate Corrosion

BY EUPHIME BERESLAVSKY

ACCORDING to the German patent No. 159,866, "for the preparation of binding materials such as portland cement, damp granulated blast-furnace slags were mixed with unslaked lime and the dry mixture obtained was reduced to powder. However, experiments proved that by applying this method the hydraulic qualities of the grains of slags can be used only superficially. In order to utilize them fully, the mixture of blast-furnace slags and unslaked lime is subjected to the action of elastic steam, after which the mixture is ground. Usually it is necessary, before grinding, to dry the mixture, after subjecting it to the action of elastic steam. In order to avoid this, the granulated slags are first subjected to the action of steam separately and afterward are mixed with the necessary quantity of unslaked lime. Thus a dry mixture is obtained, which is reduced to powder without preliminary drying in mills. The powdered product, which looks like portland cement, is then used in the same way as the latter."

As is evident from this brief synopsis, this German patent is a method of obtaining a binding material, which hardens in water, from the granulated blast-furnace slags and unslaked lime.

The general method of producing binding material (slag cement) is based on the addition of the necessary quantity of hydrated lime to the dried and granulated slags. The addition of lime depends upon the coefficient of the co-relation of the sum of alkali to the acids.

According to the above:

Composition of Slags Used	Per Cent	Composition of Cement Produced	Per Cent
CaO	41.5	CaO	45.4
MgO	3.2	MgO	2.8
SiO_2	42.0	SiO_2	35.7
Fe_2O_3	0.6	Fe_2O_3	0.9
Al_2O_3	10.8	Al_2O_3	9.7
S	1.5	S	1.4
Insoluble residue	0.4	Insoluble residue	0.5
		Loss on ignition	3.6

The tensile strength of this cement:

	Pure Kg. per Sq.Cm.	With Sand (1 Part to 3 Parts), Kg. per Sq.Cm.
After 1 day	9.6	....
After 7 days	31.2	10.5
After 28 days	38.2	24.5
After 3 months	....	29.9

TENSILE STRENGTH

The tensile strength of the cement is to a certain degree (2.0 to 2.2), according to Tenmayer, proportionate to the coefficient of the co-relation of the sum of alkalis to the acids. This coefficient of the slag, on which I experimented as above, was:

$$\frac{Al_2O_3 + CaO + MgO}{SiO_2} = \frac{9.8 + 42.6 + 1.1}{25.6} = 2.1$$

The slag, preliminarily dried and then ground in the rotary mills, was sifted by me through sieves with 4900 holes per sq.cm.

The average tensile strength (according to Mey) of the normal slag cement should be:

After 7 days	14 to 19 kg. per sq.cm.
After 28 days	20 to 27 kg. per sq.cm.
After 84 days	25 to 30 kg. per sq.cm.
After 210 days	29 to 35 kg. per sq.cm.

BREAKING STRESS OF NORMAL SLAG CEMENT

The average breaking stress of the normal slag cement (according to Mey):

After 7 days	105 to 133 kg. per sq.cm.
After 28 days	170 to 221 kg. per sq.cm.
After 84 days	220 to 260 kg. per sq.cm.
After 210 days	240 to 288 kg. per sq.cm.

In general, slag cement has less tensile strength than portland cement; however, in admixture with sand it gives reverse results. The setting of slag cement should not be as quick as that of portland cement, and in general the process of hardening should be slower. For instance, the Ashland Pozzolanic cement begins to set within 3 hours and 40 minutes and finally sets within 8 hours.

Matezius' experiments show that the granulated slag changes owing to the influence upon it of elastic steam in a closed vessel, and the mass crumbles and forms a dry powder—a cementitious and hydraulic product.

Although the conditions and nature of work unfortunately did not permit me to test it, yet I presume that if the process of slaking of lime (producing quicklime) is done in a closed vessel in connection with the process of obtaining the dry cementitious powder "matezius" from blast-furnace slags, a strong fusing material (stronger than slag cement) will be obtained if these processes are properly carried out. This, in my opinion, requires special attention.

LIME DOES NOT AFFECT HYDRAULIC QUALITIES

The quantity of lime added to the slags has no great bearing on the resistance of cement. There may be added 10 to 25 per cent of the entire weight of dry slag. To a good quality of basic slag 10, 15, 20 or 25 per cent of lime may be added without a noticeable change in its hydraulic properties. I believe that the most suitable coefficient for slag cement is about 1.9. Magnesia, of which there is in slag cement sometimes as much as 30 per cent, does not affect the hydraulicity of cement, although there is an opinion that magnesia in combination with gypsum is the cause of inconstancy of volume of cement solutions. The cementitious solution obtained from slags is of a greenish color, which is ex-

plained by the following: The slags contain sulphur in the form of MnS, CaS and $CaSO_4$ (altogether to the amount of 1 to 3 per cent). When granulating:

$$CaS + 2H_2O = Ca(OH)_2 + H_2S$$
$$3H_2S + Fe_2O_3 = 2FeS + 3H_2O + S$$

FeS gives the slag a greenish color. FeS does not affect the properties of cement; samples of it, having a very dark color, did not change in volume after being kept under water for a long time. On the other hand, in the open air it loses all color and becomes white owing to the oxidation of FeS into $FeSO_4$. $CaSO_4$ does not act detrimentally upon the properties of cement, but merely changes the speed of setting.

The tested granulated slag, which gave by itself, without addition of other materials, a breaking stress of less than 4 kg. per sq.cm. after 28 days, upon addition of quicklime (CaO) gave the following results:

90 PER CENT SLAG + 10 PER CENT CaO

Age at Test	Batch Number	Tensile Strength, Kg. per Sq.Cm.	Age at Test	Batch Number	Tensile Strength, Kg. per Sq.Cm.
7 days	1	12.9	28 days	1	36.7
	2	12.7		2	36.2
	3	13.5		3	34.5
	4	14.0		4	38.5

Hydraulic modulus 1.4.
Setting of the slag cement obtained begins after 32 minutes.
Final set within 3 to 4 hours.
Normal consistency of the solution is 31 per cent.

90 PER CENT SLAG + 2 PER CENT RUSSIAN (GLUKHOOZERSK) PORTLAND CEMENT + 10 PER CENT CaO

	Batch Number	Kg. per Sq.Cm.
After 7 days	1	14.5
	2	13.9
	3	13.6
	4	14.0

From this we gather that the admixture of a small quantity of portland cement does not affect the strength of the cement.

BREAKING STRESS

	Batch Number	Kg. per Sq.Cm
Cube with 10 per cent CaO with sand	1	198.6
	2	142.3

TENSILE STRENGTH

One part (90 per cent slag + 10 per cent CaO) to 3 parts standard sand.
Normal consistency of the solution is 9¼ per cent water:

	Batch Number	Kg. per Sq.Cm.
After 18 days	1	23.6
	2	23.2
	3	24.1
	4	24.8
	5	20.4
	6	21.4

Storage of briquets—1 days in moist air, 17 days in water.
One part (90 units slag; 2, portland cement; 10, CaO) to 3 parts of standard sand.

	Batch Number	Kg. per Sq.Cm.
After 18 days	1	20.3
	2	18.1
	3	19.2
	4	23.0

As shown above, the strength of the mixture of slag with portland cement is even somewhat smaller than without it.

Mixture of 1 part slag + 25 per cent quicklime, hydraul. modul., 1.93.

THE TENSILE STRENGTH OF BRIQUETS

Normal consistency for 1 part cement and three parts standard sand = 9¼ per cent water.

	With Sand — Batch Number	With Sand — Kg. per Sq.Cm.	Without Sand — Batch Number	Without Sand — Kg. per Sq.Cm.
After 28 days	1	150.2	1	284
	2	166.3	2	300
	3	148.7		

One day in moist air, 6 and 27 days in water.

THE BREAKING STRESS (WITH SAND)

Age at Test	Batch Number	Tensile Strength Kg. per Sq.Cm.		Age at Test	Batch Number	Tensile Strength Kg. per Sq.Cm.	
After 7 days	1	13.6	About 200 lb. per Sq.In.	After 28 days	1	28.7	About 400 lb. per Sq.In.
	2	12.0			2	26.7	
	3	12.7			3	26.9	
	4	13.8			4	27.8	

One day in moist air, 6 and 27 days in water.

THE BREAKING STRESS (WITHOUT SAND)

Normal consistency, 34 per cent water.

	Batch Number		
After 7 days	1	27.5 kg. per sq.cm.	About 400 lb. per sq.in.
	2	26.3 kg. per sq.cm.	
	3	28.0 kg. per sq.cm.	

That is, higher than normal, 20 kg. per sq.cm.

	Batch Number		
After 28 days	1	50.2 kg. per sq.cm.	About 650 lb. per sq. in.
	2	47.4 kg. per sq.cm.	
	3	46.2 kg. per sq.cm.	
	4	42.6 kg. per sq.cm.	

That is, higher than normal, 25 kg. per sq.cm.

The cement manufactured by the Russian portland cement works gives:

	Pure	Mixture
After 7 days	About 35 kg. per sq.cm. (About 500 lb. per sq.in.)	About 12 kg. per sq.cm. (170 lb. per sq.in.
After 28 days	About 45 kg. per sq.cm. (About 650 lb. per sq.in.)	About 16 kg. per sq.cm. (225 lb. per sq.in.)

Thus we can see that the cement obtained from the slags, which I tested, of the Alexandrovsk South Russian Works of the Briansk Co., without sand, was approximately equal in strength to the portland cement, and with sand even exceeded it. The cakes made of this cement had proved the constancy of its volume. Consequently, the above granulated basic slag had proved to be a suitable material for the production of slag cement of high quality.

At the beginning of the activity (1913-1914) of the above-mentioned slag works (reorganized) I had an interview with the director and supervisor of the chemical laboratory of the works and during the interview I stated my plans of working with their slags. In the summer of 1914 this plan was tried in the laboratory of these works, and later on in the shops, and gave good results. In 1917, when I visited the works, they were at the height of their productivity. Wishing to make a further study of the properties of slag and of its interaction with lime and gypsum, I applied the mathematical rule of combination of these elements.

Combinations That Are Possible

The following combinations are possible:

Elements:

1. Granulated slag.
2. Non-granulated, or, more correctly, degranulated slag.
3. Lime (quicklime).
4. Gypsum (burnt and semi-hydrous).

Possible combinations of the four elements, in twos (C_4^2):

1 and 2	2 and 3	3 and 4
1 and 3	2 and 4	.....
1 and 4	.....	.....

Combinations of the four, in threes (C_4^3):

1 2 3	2 3 4
1 3 4	2 1 4

There can be no other combinations.

Five Useful Combinations

Excepting the combinations that are useless for us, 1 and 2, 2 and 3, 3 and 4, 1, 2 and 3 and 1, 2 and 4, we have five combinations, which will serve me for my investigations. If we set aside the combination of granulated slag with lime (1 and 3), already tested, only two binary mixtures remain:

(a) Granulated slag with gypsum.

(b) Degranulated slag with gypsum.

Two ternary mixtures remain:

(a) Granulated slag with lime and gypsum.

(b) Degranulated slag with lime and gypsum.

By "degranulated" I mean the granulated slag, which I had, and in which all granulation properties had been eliminated by means of preliminary heating up to a high temperature and subsequent slow cooling in a closed kiln.

In the fusion of slag and gypsum there can finally take place such a co-relation of the component parts of the combination that it would resemble the so-called "cement bacillus," to which Candlot and Deval have given the formula Al_2O_3, 3CaO, $3CaSO_4$, 28.4 H_2O. This fusion after the hardening of the cement solution produces a large increase of volume. A small quantity of burnt gypsum, on the other hand, acts beneficially. Without altering the volume it retards the setting of the cement and increases its strength.

Finding Most Favorable "State of Balance"

The retardation of the setting is explained by the fact that burnt gypsum does not enter into interaction with $CaOH_2$. The formation of "cement bacillus" destroys this retarding influence in the setting. The finding of the most favorable "state of balance" of the component parts of the mixture of slag and gypsum is the fundamental problem of our theme. The answer can be given only approximately and as applied to the slag used in the test.

There are indications that by partial addition of gypsum to granulated slag it was possible to obtain a tensile strength of 43 kg. per sq.cm. after 28 days, but the amount of the addition and the co-relation of the gypsum elements to the others I have not been able to determine. From my investigations I would say that the addition of 10 to 15 per cent of gypsum is the most suitable, although I was not successful in obtaining thereby a very high strength in the cement.

Adding from 1 to 25 per cent to our slag we gradually approach Deval's formula, but to reach this formula absolutely, without the introduction of alumina, is impossible, as can be seen from the chemical analysis of the slag tested. By adding 25 per cent of gypsum the following compound is obtained:

Al_2O_3	CaO	$CaSO_4$
1	3	4

Combinations with this amount of $CaSO_4$ (25 per cent) and a little more (30 per cent to 35 per cent) produce negative results.

Thus cubes made of a combination of degranulated slag with 25 per cent of gypsum gave after 28 days a breaking stress of only 63 kg. per sq.cm. and tensile strength of 7.4 kg. per sq.cm. Eight-shapes of the same mixture, but with sand, gave a breaking stress after 28 days of 4 kg. per sq.cm., a slag being used in which granulation had been eliminated by means of preliminary heating up to a temperature of 1280 to 1300 deg. (No. 9 = 10 Zeger pyramid) in a gas kiln and subsequent slow cooling in a closed kiln.

Some of the briquets composed of (1) granulated slag with 5 per cent of gypsum, (2) degranulated slag with 5 per cent of gypsum, placed in water became quite soft after two days, and part disintegrated and turned almost into mud. Those of the briquets that, after remaining two days in a moist place (above water), had not been put in water, but were left for several days in the open air and then for experiment put in water, disintegrated entirely within a few hours.

Samples made of 85 parts of granulated slags to 10 parts of quicklime to 5 parts of $CaSO_4$ and 85 parts of degranulated slags to 10 parts of quicklime to 5 parts of $CaSO_4$ had swelled, cracked and changed their volumes (just as slags of same composition but with sand) after being in water for 7 days.

Effect of Adding Gypsum

Consequently, slag cement (even with an enlarged hydro-modulus) made of granulated slag and 10 per cent of quicklime, which had, as shown above, a good stress, lost its stress on addition of 5 per cent of burnt (and semi-hydrous) gypsum and also changed its volume.

When I repeated the experiments, keeping to the addition of 4 to 6 per cent of well-burnt gypsum continuously to the granulated slag and slag wherein granulation had been eliminated, the results were the same. After two days the briquets with sand, which had been lying in water, disintegrated entirely, part of briquets (without sand) changed in volume, having swelled and formed large cracks, while the slightest contact broke them up. The final hardening of the samples was sometimes not noticeable even after two days, and a touch of the finger left a mark. Other samples broke up by themselves, not having hardened completely.

With the increase of the amount of gypsum added up to 10 to 12 per cent of the total weight of the mass, the fusing properties of the hydraulic mixture began to appear thus:

90 parts of degranulated slag to 10 per cent $CaSO_4$ (burned) gave the following average:

After 7 days.....	Batch 1	10.2 kg. per sq.cm.	Or about 150 lb. per sq.in.
	Batch 2	10.7 kg. per sq.cm.	
	Batch 3	10.3 kg. per sq.cm.	
After 28 days.....	Batch 1	23.7 kg. per sq.cm.	Or about 350 lb. per sq.in.
	Batch 2	24.2 kg. per sq.cm.	
	Batch 3	22.4 kg. per sq.cm.	

When 15 per cent of $CaSO_4$ was added to the total weight of the mixture the resistances were about the same. After further additions, however, the resistances in my experiments began to fall. No change of volume was noticeable. Parts of matte cement remained firm and hard and showed no signs of distortion, cracking, checking or disintegration in the steam test for soundness. The beginning and final setting I tested with the Vicat apparatus. Setting commenced on the average after 15 to 25 minutes and final setting took place after a few hours.

How Lime and Gypsum Influence the Constancy of Volume and the Setting of Cement

We shall now consider lime and gypsum as factors influencing the constancy of volume and the setting of cement.

According to Dr. Kuhl's report before the Society of German Manufacturers of Portland Cement in 1912,[1] the increase of volume $Ca(OH)_2$ during the hydration of the component parts of the cement clinker produces inconstancy of the fusing material. This, however, does

[1]Russian Journal "Cement," Vol. I, 1914.

not always happen. Kuhl's supposition was that the hardened cement has a certain space for the formation of $Ca(OH)_2$; that is, certain processes take place in connection with the reduction of volume, thereby creating the necessary space for the appearing hydrate of lime. In hardening, one part of the lime changes into hydrate, while the other part forms hydraulic silicates and aluminate. These processes act as if in completion of one another and in certain co-relations no change of volume takes place. The resistances within the paste are then equalized by counter forces outside. As is known inconstancy of volume is also the result of a too great content of gypsum. This is considered by Kuhl in the same light as the above in connection with the decrease or increase of volume during the hardening of the cement. The hydrate of the lime in this instance is substituted by sulpho-aluminate lime (according to Le Chatelier Al_2O_3, 3CaO, $3CaSO_3$, 28.4 H_2O), or as Michaelis calls it, "cement bacillus," formed of gypsum and hydraulic aluminate of lime.

As I have remarked, the inconstancy of volume is caused by the content of too much gypsum; it does not follow, however, that gypsum is always harmful, as it changes the volume in hardening. On the contrary, where there is not a sufficient amount of hydrate of lime to obtain high strength and not all the free space in the thick of the lime is filled by it, the presence of "cement bacillus" is indeed very useful, as it fills up the space remaining empty.

Therefore, reviewing the inconstancy of volume of cement in connection with gypsum, we must consider it as depending not only upon the amount of gypsum itself, but also in a great measure upon the amount of lime in the cement.

Placing the content of gypsum in the cement in connection with the amount of lime, Dr. Kuhl cited a number of examples proving that as a matter of fact with a low hydro-modulus of portland cements, as for instance, with a hydro-modulus of 1.85, 6 per cent of $CaSO_4$ is required, while with a hydro-modulus of 2.3 only 0 to 1½ per cent is necessary for best strength with no modification of volume.

It is now considered as proved that inconstancy of volume from gypsum depends not on the absolute amount of lime, but upon the relation of gypsum to lime, and that this is especially observed in cements obtained from blast-furnace slags. According to Kuhl, blast-furnace slag granulated in water, with an addition of 3 per cent of gypsum, after 28 days (hardening under water in mixture with sand 1 part to 3 parts) had a tensile strength of 6 kg. per sq.cm. and breaking stress 38 kg. per sq.cm. Owing to the increased addition of gypsum, the 28 days strength of the hydrated samples grew progressively for tensile strength, 27 and 40 and 43 kg. per sq.cm., and for breaking stress, 196 and 412 and finally 604 kg. per sq.cm.

As has been remarked by Kuhl (this has been corroborated by builders in the south of Russia in port construction in the Azov and Black Seas), the relation of cements with poor content of lime to gypsum makes them especially suitable for marine construction; as the cement is the less sensitive to the acid substances of sea water the more gypsum the cement can take in without disturbing the constancy of volume. The more lime is substituted by gypsum, the more suitable will the cement be for marine construction.

Cements that require considerable amounts of gypsum (10 per cent and more) in order to evidence good properties become immune from the destructive action of sulphuric acids; they are inoculated, so to speak. The corresponding action of the gypsum that forms subsequently will be the weaker according as more gypsum is contained in the cement originally.

Conclusion

Cement prepared with a corresponding co-relation of gypsum and slag and properly prepared can be used in the construction of quays, cisterns, reservoirs, canals, bridge supports, etc. When used for molding stones and artificial marble, which may break by rapid drying, they should at first be moistened.

In conclusion I wish to mention the following additional points:

1. Various cements obtained from blast-furnace slags, when they are the most important component parts (in per cent) of the raw material obtained, cannot and shall not be accepted on the general rules applied to ordinary portland cement. For the acceptance of above mentioned cements the content of sulphuric anhydrate (SO_3) in them must be found in a quantity of more than 2 per cent and even in higher quantities in order to secure their physical and mechanical properties and their resistances, as demanded by the standard regulations for portland cement.

2. A change of this sort makes it possible to utilize properly, without endangering the strength of the buildings, those rather large quantities of slags which have accumulated during the war at the metallurgical works and which cannot be worked into cement in any other way.

Although such cement would not answer in its chemical composition to the standard international specifications, a very fine and cheap cement could be obtained from these slags if the manufacture of it is properly organized.

The Present Status of Oil Shales

MUCH publicity of various sorts has recently been accorded the huge deposits of oil shales occuring in the Uintah Basin, occupying the northeastern portion of Utah south of the Uintah Mountains and extending eastward into Colorado. A less-known region of western Wyoming occupying the Green River Basin northward from the Uintah Mountains to the Wind River Mountains probably contains an even greater area of oil shale beds. A third deposit of enormous size lies astride the Colorado-Wyoming border sixty miles further east.

In addition to these tremendous and only roughly-mapped regions, an area of about 2500 square miles of good oil shale has been located in the central part of Utah, near Manti. Near the station of Elko, Nevada, on the Western Pacific Railroad, occurs a relatively small area upon which many locations have been made. In fact patches of oil shales up to 100 square miles in extent may be found at numerous spots all over the Rocky Mountain region. These are in addition to the numerous small areas of asphaltic sandstones (popu-

larly known as "oil sands") scattered through the Western plateau, in area up to a few townships. Of the latter, a well known and large irregular deposit occurs in the San Raphael swell 60 miles south of Price, Utah, and another near White Rock in northeastern Utah.

Superficial Appearance

The shales themselves vary greatly in superficial appearance as well as in physical properties. Thus, the color, specific gravity and yield change in perfectly discontinuous fashion, so that about the only generalization one may make is that eye-examination tells nothing as to the possibilities of the sample. Broadly speaking, it may also be said that differences in appearance are

FIG. 1. HELL'S HOLE CANYON, NEAR WHITE RIVER, UTAH

regional rather than stratigraphical; the layers in a bed at a certain locality frequently look much alike, but may vary greatly in oil content. As is only natural from the wide distribution and immensity of the deposits, the amount of lean overburden above the workable seams is also subject to large variation. Usually oil-shale beds will be exposed on the high, steep-sided bluffs cut by river erosion, as is shown in Fig. 1, while the back country shows few outcrops; in general the rolling surface consists of more or less disintegrated rock, quite often of shale which has lost but little of its original carbonaceous matter by atmospheric oxidation. Sometimes rivers have carved valleys hundreds of feet deep through kerogen-bearing strata without reaching barren material. It is also fortunate that the areas were not folded to any great extent in their upheaval from the ocean bed, nor are they buried to any depth under other sediments of more recent date. In this as well as many other characteristics our Western shales are so different from those treated by the oft-quoted Scottish industry that analogies cannot be drawn safely.

Nature of Kerogens

The geological origin of the shales is a matter of considerable interest, but as yet the problem has not been definitely solved. Since there seems to be a complete and unbroken series from lean oil shales to lignites, information on such coals should be illuminating. According to Potonié and Heinold, non-bituminous lignite coals were formed at regions where extensive subtropical flora grew in swamps and where the remains of this vegetation accumulated into a peat bog. Sand or clay then collected during a subsidence of the ground, and this impervious covering protected the carbonaceous deposit from entirely rotting away. The bituminous lignites were formed in the same regions during droughts, when the cellulose exposed to the air decomposed to water and carbon dioxide, while the fats and wax resins remained intact. Bituminous shales were formed largely of these unoxidized organic remains swept down by rivers into a deep, quiescent lake or arm of the sea. Many traces of animal life have also been identified in oil shales; Western shales also contain more or less carbonate, probably organic in origin. Thus, these complex hydrocarbons, the remains of animal and vegetable life, were deposited during the building of the sedimentary beds by the accumulation of the smallest particles of inorganic sediment—largely calcium, magnesium and aluminium silicates. During the long stretch of time the beds became of tremendous thickness, and eventually, by a change in the geological conditions, were overlain by other sediments carrying no carbonaceous matter, and pressure-metamorphosed into shale beds (Fig. 2).

One great distinction holds between the oil-forming materials of shale and bituminous lignites, however, which is not explained by the preceding theory. This is that the bitumen in lignite is soluble in many common organic liquids, such as benzol, alcohol and carbon disulphide, while the carbonaceous materials of Messel coal and oil shales (particularly Scottish shales) are not soluble to any great extent. The definition of the term "bitumen" has consequently been stretched to cover all substances which furnish oils and tar when subjected to dry distillation. Brown's suggestion is better: Call the organic remains in shales "kerogens," since they are substances capable of producing oils, and yet are apparently neither bitumen, petroleum nor resin.

Foreign vs. American Processes

Bituminous lignites and shales have been retorted in Germany, Scotland and France for many years. Each material produces a variety of gaseous and oily fractions, together with solid paraffines and coke. Even with the

FIG. 2. CLOSE VIEW OF AN OIL SHALE FORMATION
(Courtesy of the D. & R. G. Ry.)

low price of foreign labor, the sale of the coke resulting from lignite-retorting is the return which keeps these enterprises alive; while the Scottish shale industry exists by virtue of the ammonia recovered as a "by-product." In the development of these foreign processes almost every conceivable type of retort was "invented," and many of them tried in practice. The early investi-

gators soon found themselves on the horns of a dilemma —intermittent retorts successfully produced gas, oil and coke, but were of very low capacity. On the other hand continuous retorts gave bigger tonnage but an incomplete recovery, and the oils produced were of low quality. Many trials resulted in the survival of gas-heated vertical retorts lined with iron and brick, with a slowly descending charge column. By means of heating flues built in the sidewalls of the shafts, the temperature is closely controlled; indeed, such regulation is absolutely essential for the production of satisfactory volatiles and residues.

Apparently the first thing which an American does when he discovers the existence of oil shale is to invent a process or furnace for getting the oil. Scores of patents have been issued, but it is doubtful if many of them are commercially plausible, and questionable whether the best of these present any improvement or addition to previous knowledge which will withstand a legal attack. In the attempt to reduce the modest amount of labor required by the successful Scottish retorts, many mechanical monstrosities have been evolved whose operation would require a gang of mechanics and a heap of repair parts. Others exhibit the utmost ignorance not alone of distillation methods, but of furnace design and the principles of combustion and chemistry. It would seem that some company organized primarily to get shale oil would be well advised to erect Scottish retorts and adapt them to local conditions. These well-tried furnaces are mechanically good —they operate on recovered gas with a minimum of labor, make a good yield of satisfactory crude oil with an increasing amount of paraffine, and permit the recovery of large amounts of ammonium sulphate. Should labor-saving devices be considered essential, the modern by-product coke oven with its marvellous mechanical equipment could be taken as a model, and so modified as to produce the regular temperature cycle needed for maximum yield.

As a matter of fact, on Dec. 1, 1918, of all the proposed processes and organized companies, not one was producing crude oil. In addition to this fact, there are but two or three plants ready to operate on a commercial scale—that is to say, for more than small-scale experimentation. One may understand how much of the shale agitation is merely words when it is doubtful if more than twenty barrels of crude have been produced to date from Western shale!

Construction at Elko and Watson

Perhaps the most promising attempt now under way is that financed by the Southern Pacific railroad at Elko, Nevada, where this company is erecting a Henderson retort (Scottish) for distilling shale. The Bureau of Mines is co-operating with this effort and has detailed David T. Day to act as consulting chemist. With adequate financial support and technical supervision, this attempt to adapt successful foreign practice to a local deposit should produce a mass of invaluable information.

In the Uintah basin, at Watson, Utah, the end of a 60-mile narrow-gage railroad running northwest from Mack, Colorado, the Ute Oil Co. is planning to install a 400-ton plant on the so-called "Wallace process." The bulk of the material for this plant is now on the ground, but actual construction has not yet started. The Wallace process is discontinuous and uses a vertical retort, heated from the outside. Vaporized hydrocarbons are to be withdrawn through a perforated tube extending axially down the retort. It is stated that the heating period is to be 55 minutes, which is approximately 5 per cent of the time used in passing the charge through the Scottish furnaces. It is also doubtful whether the mechanical contrivances proposed for charging and discharging will sufficiently counteract the inherent disadvantages of intermittent operation.

Activity at DeBeque

DeBeque, in western Colorado on the Denver and Rio Grande Railway, may be regarded as the center of the oil shale boom. At or near here are the sites of three plants, at each of which some work has been done. The American Shale Refinery Co. is putting up a so-called "Wingett retort," which is somewhat similar to a tall Wedge roaster. It is understood that the shale will be crushed to 10 mesh, and that the rabble arms will travel at about 30 rotations per minute! The inventor thinks he can charge 100 tons of shale per day, but as yet has no information as to whether the retort will deliver crude oil, or merely dust.

DeBeque is the scene of operations of the Mt. Logan Oil Co., which has three 20-ton units of the Galloupe process on the ground, but not yet installed. This is a long, inclined retort of crescent cross section so set that the heating gases play upon the cylindrical bottom, and contains a stirring arm manually oscillated. Volatiles are removed from the outer edges.

Two small modified Henderson retorts were erected near DeBeque about a year ago by the Oil Shale Mining Co. One of these was operated for a short while at the time of completion, and the other given short trials recently, but not much oil was made in either attempt. This company has six 6-ton units on the ground, but is not producing any oil at the present time.

Products of Distillation

Thus it appears that little of the energy so far devoted to this subject has carried the enthusiasts to the producing stage. Indeed, little is known of the substances which will be produced upon retorting. Evidently the assumption has been generally made that the products will be somewhat analogous to those of the Scottish industry. Here sufficient permanent gas is evolved to operate the process, and the crude oil is successfully fractionated and marketed as naphtha, lamp oil, gas oil, lubricating oils and paraffines by processes very similar to those in use in petroleum refineries. On the other hand, what little work has been published on Western shales show that the products of retorting are quite different from the ordinary oils of commerce. Thus, Morrell and Egloff in Chemical & Metallurgical Engineering, Vol. 19, p. 90, (July 15, 1918), and Dr. W. D. Bonner, working independently at the University of Utah, have all shown that the oils are full of highly unsaturated compounds, that they contain considerable nitrogen and sulphur and that the ordinary method of fractionating followed by acid-soda treatment does not produce stable oils of correct color, odor, specific gravity and volatility to be readily absorbed by the American market except at the expense of prohibi-

tive treatment losses. Predictions that the oil shales would produce billions of barrels of gasoline are not founded on correct premises, for the percentage of low-volatile compounds are less than assumed, and this fraction is not a distillate suitable for internal-combustion engines, since it contains its share of the complex compounds contained in the crude. Even the amount of recoverable nitrogen is so small as to reduce seriously the income from this source. Thus, the shale banks so far tested contain on the average not more than 0.6 to 0.7 per cent nitrogen. Suppose half of this is recoverable as ammonium sulphate, which would be most excellent practice from a retorter's standpoint, the shale would yield 25 or 30 pounds per ton under most favorable conditions—markedly less than that of Scottish practice. As a matter of fact the best ammonia recovery had in Dr. Bonner's work amounted to but 10 per cent of the nitrogen contents.

These statements should not be interpreted as meaning that our immense deposits of oil shale cannot be counted upon eventually to supplement the petroleum production. It cannot be too strongly urged, however, that the successful exploitation of these reserves will require the most painstaking and persistent research on the part of a competent technical and selling staff—either a retorting process must be discovered which will produce good yields of normal crude, or easy methods perfected to separate the unstable compounds, uses discovered for them, and the market educated to absorb them. Evidently this development is impossible as long as the promotor remains the prominent feature of the situation!

Treatment of Asphaltic Sandstone

A sharp distinction should be drawn between the preceding discussion of oil shales and the following information on asphaltic sandstones. As already stated, these so-called "oil sands" occur in thick and extensive deposits at many scattered localities throughout the Rocky Mountains. They consist of beds of fine, rounded sand, cemented with a heavy asphaltic oil; their nature suggests that they represent the remains of a petroleum deposit which has been so exposed that the lighter oils have evaporated, leaving the heavier residue behind.

That the kerogen in asphaltic sandstone is essentially different from that in oil shale is evidenced by the fact that it can be easily leached from the sandy aggregate by gasoline and other organic solvents. This has been done in a continuous manner at the University of Utah. A traveling belt operating in a closed leaching tank elevated the sandy residue above the surface of the digesting liquid, there to be sprayed first with solvent decanted from the sump, and later by clear gasoline recovered from the stripping still and discharge trap. The well known system of continuous counter-current decantation perfected for cyaniding and applied to numerous chemical and metallurgical leaching processes comes to mind as being quite applicable for this extraction. Covered agitators and thickeners would be used—in fact the whole system would be gas-tight in order to prevent the volatilization of the solvent, while the final sludge would pass through a filter and drier to recover the last of the gasoline or other leaching medium. The rich solutions thus formed may be separated from the solvent in a stripping still. The liquid residue is a heavy viscous oil, which is about 10 deg. Baume gravity yielding little material under 200 deg. C. when distilled. As far as studied, it appears to be quite similar to the heavy parts of Mexican and Californian petroleum, and will yield gasoline by cracking, lubricating oils, road tars and coke of marketable quality and by ordinary refining methods.

Large scale experimentation on distilling this asphaltic sandstone is to be undertaken at Casmalia, California, a point on the Southern Pacific railroad near Santa Maria, where a so-called "Day-Reed" plant is being built. The furnace consists of three tubular retorts, egg-shaped in cross section, set one above another between headers, and the whole mounted in a rectangular furnace. The retorts themselves are about 20 feet long by 15 inches high. The broken standstone enters one end of the top retort and is worked slowly to the other end by a screw conveyor; it falls through the header into the second retort, and is worked back and forth through the remaining retorts in a similar manner. Suitable exits for gas, light and heavy oils are provided.

Power at Pittsburgh

AT THE last local meeting of the American Electrochemical Society at Pittsburgh, the program was opened by a fine paper from Dr. J. F. Schrader of the Westinghouse Research Laboratory, who described the latest devices for the "Production and Measurement of High Vacua." The paper was illustrated by slides.

This was followed by an informal symposium on the electric and electrochemical interests of the Pittsburgh region. In the course of this some interesting notes by Carl G. Schluederberg, the well known "live wire" of the Westinghouse Electric & Manufacturing Co., brought out the fact that the Niagara power costs may possibly be reached in the Pittsburgh region before long. It used to be said that there would never be any such power supply at Pittsburgh to equal, say, 500,000 hp. But the statement was made that some large interests are planning now for huge plants, both coal at the mine and water power, which will give a total of nearly 700,000 kilowatts. The statement was also made that the cost of this power would, when normal conditions arrive, presumably be as low as that of power anywhere in this country.

This symposium was only the prelude to an interesting series of papers of the general electric outlook in the Pittsburgh region which it is planned to bring out before the Pittsburgh Section this winter. Interest in the local Section and its work is growing, through the energetic work of the chairman for the last year, Mr. R. E. Zimmerman of the Research Laboratory of the American Sheet & Tin Plate Co. at Pittsburgh.

Pro Patria, Pro Meter, Pro Liter

In the announcement put forth by the American Metric Association a new slogan has been adopted which reads "Pro Patria, pro meter, pro liter!" We favor the idea. At the same time we wonder whether the phrase is entirely happy. In most of us our school-boy Latin has so degenerated that we are apt to read a false meaning into the simplest expressions in the language. For instance the new slogan may unhappily be translated, "For Father, for Mother, and for a Long Drink."

Mercury Production at Almaden, Spain

Statement of Marketing Conditions—Contract with Rothschild of London and the Method by Which the Price Is Controlled—Ore Sorting and Sampling—Bustamente and Cermak Furnaces—Condensers—Production and Costs

By Dr. ROLAND STERNER-RAINER[1]

COMPARISON of production statistics, shown in Fig. 1, the world over shows that Europe has regained the lead since the peak of California's production, which occurred in the '70s of the last century. It also seems that Europe will increase its lead. Three European states at present produce a considerable part of the world's output. In the past year Spain led the production with 1500 metric tons;[2] then follows Italy with nearly 1000 metric tons, and then Austria-Hungary with nearly 850 metric tons. Besides the three largest quicksilver mines in the world—Almaden, Monte Amiata and Idria, which give the above-mentioned countries the lead in production—there are in Europe a number of smaller mines which produce notable amounts of quicksilver, either directly or as a by-product. Since, in general, there is little of interest in the method of ore dressing and reduction employed by these small plants, this section will concern itself mainly with the first of the large plants mentioned.

Environs of Almaden

The mining town of Almaden lies in the Spanish province of New Castle, near the boundary of Estremadura, and is somewhat off the road of travel—as most mining towns are. The railroad connecting Madrid with Portugal, via the Spanish border town of Bajodoz, passes through the village of Almadenejos, in the province of Ciudad-Real. The railroad station is called Chillon, and from here the city is reached over a stony road about 10 km. long. Almaden lies on the north slope of the Sierra Morena, in the highlands of central Castile, about 700 m. above sea level; the surrounding country is unproductive pasture land crossed by rocky escarpments. The whitewashed, one-story houses of the 8000 inhabitants lie mostly along one long, cobblestone road which runs along the ridge of a low hill which rises toward the west and reaches its highest elevation at the end of the city, where an old Moorish fort rests upon the crown of the hill. Most of the shafts are found a little farther on, and at the foot of the hill is the metallurgical plant, which is connected with the mines by an incline, the so-called "Plano-Automotor."

Of the earliest history of the plant no more is known than is recorded in the book of the engineer Cyarzabal, of which only one copy exists, in possession of the management. Little has been published about the ore occurrence, mining methods, metallurgy and production other than that found in various text books.

The ore bodies of Almaden, which extend under the city, are found only in the Silurian, which consists of clay slates, interbedded limestones and quartzites, which latter pass into micaceous sandstones. Three of these quartzites, having an average thickness of 8 to 14 meters, are impregnated with cinnabar. They merge gradually into the barren quartzites, but have a sharp contact with the slates. These ore bodies have become richer in depth, whereas several others in the neighborhood, as at Almadenejos and in the Val de Azogues, where La Concepcion is the oldest of the now abandoned quicksilver mines of the district, became impoverished in depth. Besides cinnabar, small quantities of "azogue virgin," or metallic quicksilver, are found. Pyrite is also present, as are traces of selenium and arsenic. Gangue minerals are almost entirely absent and are confined to a little heavy spar, dolomite and small vugs of bituminous matter.

The main ore body has an average assay value of 14 to 15 per cent mercury, while the two northerly ore bodies, which are not as large, carry lower-grade ore in part, the content of which may be as low as 2.5 per cent mercury. The average content of the ore treated during the last years has remained fairly constant and equals 11 per cent mercury;[3] the width of the ore zones is greater, if anything, than in past years. The production, however, has not been increased, even though the ore at present developed assures a forty-year life of the property with an annual production of 1000 metric tons of quicksilver. With this reserve the production could, of course, be increased to any desired figure.

Method of Controlling Price

The production has not been increased, because overproduction might so lower the price that the advantages of increased production would be nullified. Even though the Spanish Government is bound by contract to sell the entire quicksilver production through the House of Rothschild in London, enabling the latter to regulate the price by controlling the amount of quicksilver placed on the market, other quicksilver-producing countries, due to their production, are powerful enough to prevent a quicksilver monopoly on the part of Rothschild.

The contract of the Spanish Government, the sole

[1] A portion of an article published in "Osterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. 62, 1914, p. 529. Translated by C. N. Schuette in connection with a coöperative investigation of the metallurgy of mercury being carried on by the United States Bureau of Mines, and the New Idria Quicksilver Mining Co., and published by their courtesy.

[2] 1 metric ton = 1000 kg. = 2204.6 lb.

[3] (Translator's note.) The quantity of ore treated, presumably in the year 1912, is given later as 16,600 metric tons. The quicksilver production for this period is 35,400 flasks, corresponding to 2.13 flasks (34.5 kg.) per ton, or a yield of 7.35 per cent of the weight of the ore treated. The discrepancy between this and the average content of the ore as here stated is probably due partly to loss in treatment, which is known to be large, and partly to errors in sampling. It is generally believed by quicksilver operators that samples, as usually taken, give results indicating a higher grade of ore than actually occurs.

owner of the mines, with Rothschild was closed as a result of a public competitive submission of proposals. The contract dates from Jan. 1, 1912, and is effective for ten years. Of the total amount of quicksilver produced by the mines of Almaden, 500 flasks are reserved to the national industries of Spain. All else is included in the contract. The contractor binds himself to sell, in London, the greatest possible quantity of mercury, which he takes over f.o.b. reduction plant at a price of more than seven pounds (libres) per flask. In return for the observance of this obligation, he receives: 1. A commission of 1.25 per cent of the net value of the sales. 2. Six shillings (chelines) for each flask that he transports to London. 3. Ten per cent of the sales price above £8:2 on any sales made above this figure.

Ore Sorting and Sampling

In order to prepare the run-of-mine ore for future treatment (a "preparacion mecanica," or ore-dressing plant, has been planned but not erected) it is transported to a large sorting floor in ox-carts; here the ore is roughly sorted by hand. High-grade ore, distinguishable by its bright color, is put aside, as is the lower-grade ore and the very low-grade wall-rock. Barren rock, bricks and wood refuse is picked out. From the remainder of the ore the larger pieces are separated with iron rakes. This ore is then screened on screens having a 5-cm. opening, thus separating the coarse and fine. After the largest pieces of the two classes of higher-grade ore and a part of the very low-grade ore have been hand-cobbed to fist size, the following grades may be distinguished:

Class I. "Metal," contains about 22 per cent Hg

Class II. "China," contains about 9 per cent Hg

Class III. "Solera," contains about 3 per cent Hg

and finally the fine ore, a mixture of the comminuted material of all classes called "vasisco," with a content of about 5 to 7 per cent mercury. During the last year 16,600 metric tons of ore were treated at the plant, of which about 13 per cent was classed as "metal," 38 per cent as "china," 34 per cent as "solera" and 15 per cent as "vasisco."

The ore is sampled in the carts and cars which transport it to the furnaces. The assay sample is mixed with hammerscales and red lead in a porcelain crucible having a gold-leaf cover and heated for three minutes. The sampling and assaying are very carelessly done. Complete analyses of the ore are not available, as the assay office is not equipped for exact work and lacks a competent analyst.

Operation of Bustamente Furnaces

By far the greater part of the ore is treated in eleven twin furnaces, "hornos Bustamente" or "hornos de aludeles" (Fig. 2). Since all of the larger metallurgical plants have long since replaced this wasteful apparatus with modern installations, Almaden is one of the few localities in Europe where this historic furnace (invented by the Peruvian Dr. Don Lopez Saaverda-Barba in 1633 at Huancavelica and introduced into Almaden by Don Alfonso Bustamente in 1646) is extensively operated. The furnace erected at that time (1646) is still in operation, while the last one was erected in 1882. Construction of this shaft furnace is too well known from the text books[4] to warrant comment here.

When the furnace operation is to be resumed it becomes necessary to draw the still warm furnace tailings, which carry about 0.012 per cent. The furnace tails are carried to the dump, which in the course of time has become tremendous, in saddle baskets on mule back. First, the larger pieces of "solera" are introduced into the shaft, the object being to prevent fine ore from falling through the convex brick grate. On this is placed "china," then "metal" and finally briquets of soot and "vasisco." On top of the ore several pans of fresh soot are placed supported by a sheet metal frame. The lump ore is charged through the side doors as far as possible, the rest being dropped through the top charge door. When both openings are closed the furnace is fired, and the ores burned for two days. After the fire has been drawn, the side and charge doors are opened to allow the cold air to enter the furnace shaft and cool the tailings.

Then the "levante," or clean-up, is started. The connections between the ascending and descending condenser branches are severed and the "aludels," also called "canos," which lead from the furnace, are taken out and placed on the aludel floor, where the quicksilver flows out and the greater part of the soot is collected.

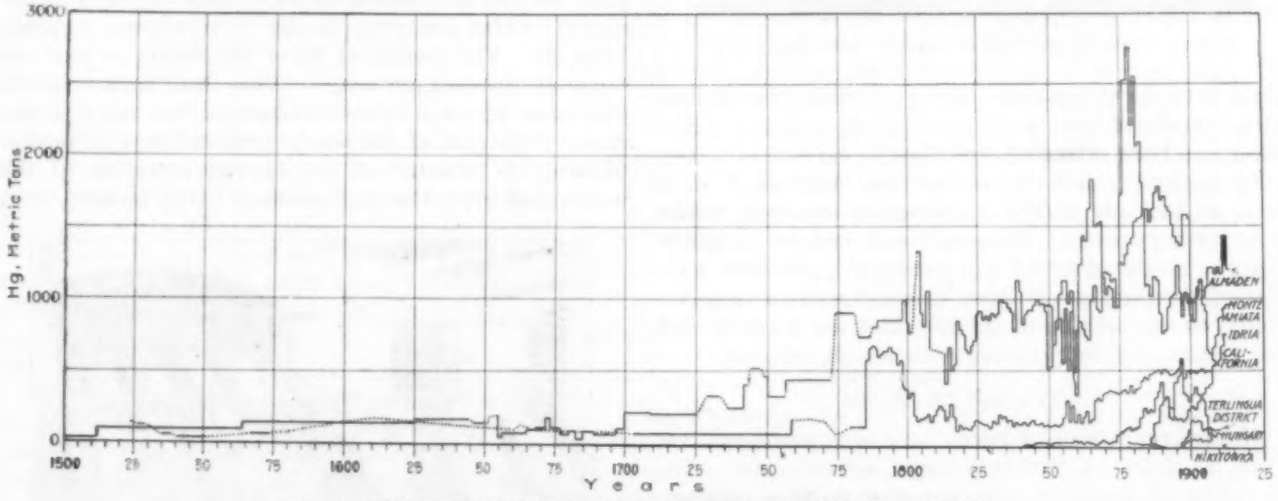


FIG. 1. WORLD'S PRODUCTION OF MERCURY FROM 1500 TO 1912

[4]Schnabel, C., Handbook of Metallurgy, Vol. 2, p. 348.

The emptied aludels, which resemble porous clay pots without a bottom, are set on the clean floor, the latter being swept from the furnaces down to the central gutter when the aludels are replaced immediately. Broken aludels are replaced by new ones of local manufacture which cost 30 centimos, and the old ones are burned in the next furnace charge. The joints between aludels are luted with a ferruginous red clay found in the neighborhood, and the furnace is ready for the next charge. The free quicksilver runs off through a floor drain into a pot below, from which an iron pipe con-

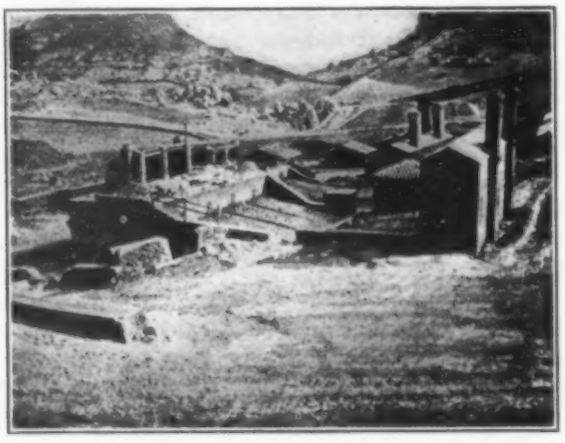


FIG. 2. BUSTAMENTE FURNACE AT ALMADEN

ducts it to the storehouse. The high-grade soot is hoed with perforated hoes until most of the trapped quicksilver has been extracted, and then is carried in woven hand baskets, called "espuertas" or "capassos," to a room at the side of the condensation chamber, where it is further treated. A considerable amount of quicksilver is scattered by all this handling. One finds puddles of mercury on all these furnaces and in their vicinity, to say nothing of the fact that the masonry and the ground are impregnated with visible droplets.

Estimation of Losses

No determinations of losses have been made, and not even estimates of probable losses are at hand. The sampling as practiced does not give reliable information as to the furnace input. It may be taken for granted that the diffusion of mercury fumes is enormous, considering the large surface presented by the lines of aludels. A considerable volume of the furnace gas escapes through the small hole in the bottom of each aludel, which is designed to afford a means of escape for the condensed quicksilver. The luting of the aludels is not so perfect as to prevent a light blue haze from hanging over them. Many of the aludels are covered with droplets of mercury on the outside, a sign that the metal was condensed when escaping. Further condensation in the fume chamber, which is divided only into two parts, is not capable of completely separating all the mercury which passes the aludel strings. The operation of the plant is discontinued during the first days of May, to be resumed during the cool days of autumn, as the hot sun practically prevents the condensation of mercury in the aludels. At that, the losses during the winter months must be very high, which is significant when the high grade of the ore and the amount of mercury produced is considered. Officially, losses are given as 3 per cent, which would amount to 36,000 kg. of mercury semi-annually, but considering all factors, it would probably be more nearly correct to place the loss at four or five times that figure.

The charge of a twin furnace consisted of 5400 kg. "metal," 9960 kg. "china," 2800 kg. "solera," 800 kg. of briquetted soot and "vasisco" and a part of the soot of the previous run. From this charge 2140 kg. of metallic mercury were recovered with a fuel consumption of 18 metric centners[5] of coal. Occasionally coke fuel is used, of which only 12 q. are used, since the preliminary heating is done by 1 metric centner of wood and 2 metric centners of coal. Two firemen control the operation. One foreman, 2 bosses, 6 men to charge the furnace and 2 to lute the aludels are necessary for a clean-up.

Cermak Furnaces and Condensers

Cyarzabal, when manager of the plant, introduced a Livermore furnace in order to increase the capacity of the plant for treating fines. This furnace was in operation until the year 1903, when it was replaced by three fine-ore furnaces of the Cermak-Spirek system[6].

In order to treat the low-grade coarse ore successfully, two twin-shaft furnaces of Spirek's design were erected. Both types of furnace are equipped with primitive Cermak condensers called "canos curvos y canos rectos," which are made locally of reinforced concrete (Fig. 3). The cooling of these condensers is poor because of the lack of water. They lead to a common flue from which a blower discharges the gases to the stack. This part of the plant, contained in a large new building, is situated at the highest elevation of the works, and gives the impression of being modern, even

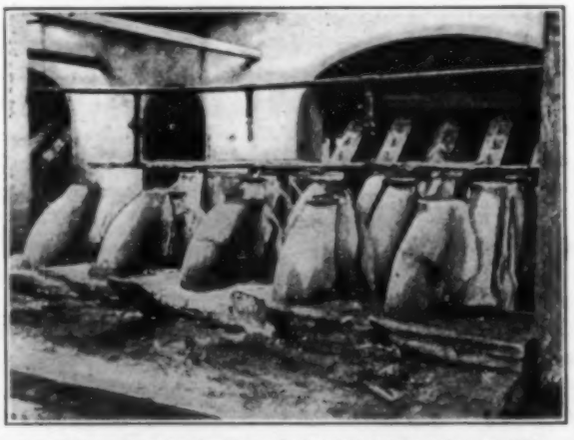


FIG. 3. CERMAK CONDENSER AT ALMADEN

though it is poorly kept up. The performance of these furnaces is considered excellent, but a thorough reform of the entire plant practice is not even thought of because the richness of the ore bodies allows any amount of waste and because laws safeguarding the health of the workingmen do not seem to exist.

The three "hornos de menudo," that is, the iron-sheathed, fine-ore furnaces, two of which have a ca-

[5](Translator's note.) Metric centner, also called double centner = one quintal (q) = 100 kg. = 220.5 lb.

[6]Schnabel Handbook of Metallurgy, Vol. 2, p. 393. The Mineral Industry, New York, 1898 to 1902. Jahrbuch der Bergakademien, Vienna, 1900. Berichte der Weltausstellungen, Paris, 1899 to 1900. Z. f. angew. Chem., 1901 to 1905. Annales des Mines Belgique, Tom. IX, 1904. Congres international des mines, de la metallurgie, etc., Liege 25, 6, 1905. La metallurgia del mercurio VI. Congresso Internationale della chimica applicata, Rom, 1906.

pacity of 8 metric tons per 24 hours, the other 4 metric tons per 24 hours, treat 20,000 kg. "vasisco," passing a 5-cm. screen with a fuel consumption of 166 kg. of coal. The "hornos de torre," or shaft furnaces, treat 28,000 kg. "solera," with a fuel consumption of 650 kg. of coke. Eight men operate the furnaces in eight-hour shifts. The fine-ore furnaces have a special exit pipe to draw off the mercury fumes, or "vasos," from under the top row of tile, and the shaft furnaces are provided with double-charge doors. Despite these precautions the charge is never free from fume, and a halfway breathable atmosphere can only be maintained on the charge floor when the hopper is filled with a layer of "vasisco" after each charge. The ore is so rich that a continuous stream of quicksilver flows from the condensers to the storeroom. The soot is gathered into boxes during the clean-up and worked with a hoe called "rodillo." The soot-rejects are mixed with "vasisco," briquetted and burned in the Bustamente furnace, or it is added to the shaft-furnace charge. In the future it is proposed to press the soot-rejects in a cylindrical form so that they can be treated in quantity with the lump ore. The clean-ups, or "limpios," are run once a year, that is, when the "campana" is completed and repairs are undertaken; this is done in the beginning of May. These "limpios" net about 27,000 kg. of metal.

Production and Costs

The mercury stored in the storeroom is shipped in seamless Mannesmann-steel bottles which are manufactured by the Domingo de Orneta Co., at a price of 6 pesetas 10 centimos each ($1.20). Generally, old bottles that have been redeemed in London and sent back to Almaden are used. A counterbalanced sheet-iron funnel having an iron draincock serves as a weighing bucket. It is filled with 34.507 kg. of mercury[1]. This mercury is drained into the flask, which when stoppered, is ready for market.

The future production of Almaden will be on the same scale as in the past. The total production of Almaden, according to the statistics at the works, is 5,089,041 flasks. Despite these favorable conditions, the production costs at Almaden are the highest. The cost of 138 pesetas ($26.63) per ton of ore treated (figures for 1905 as given by the Revista minera, etc.) shows their production cost to be seven times as great as at Idria, where the ore is only one-tenth as rich.

Statistics of Production

According to the statistics of the Frankfurter Metallurgische Gesellschaft, the following is the production of Spain, which includes that of Asturia and other minor sources:

	Metric Tons
1900	1095
1901	754
1902	1425
1903	968
1904	1130
1905	853
1906	1567
1907	1212
1908	1068
1909	1393
1910	1114
1911	1486
1912	1490

The last figure (1490 metric tons) equals 43,800 flasks of 75 lb. (29.4 flasks of 75 lb. per metric ton).

[1]Old Spanish contner = 76 lb.

Notes on the Chemical Analysis of Red Lead

By W. F. Edwards
Studebaker Corporation, Detroit, Mich.

Red lead is an important industrial material of varying content of "true red lead," Pb_3O_4, and litharge, PbO, together with small per cents of metallic lead. A Navy Department specification calls for 94 per cent "true red lead," the balance to be practically pure lead monoxide, not more than 0.1 per cent of metallic lead being permissible.

Direct methods for determining the amounts of "free" lead monoxide (litharge) and metallic lead are usually not given in schemes for the analysis of red lead, and there is a variety of methods given by different authorities on paint analysis for the determination of the "true red lead."

All schemes for the analysis of red lead base the determination of the "true red lead," assumed to be $PbO, 2PbO$, on the oxidizing action of the PbO_2 part on such substances as oxalic acid, potassium iodide, ammonium ferrous sulphate, stannous chloride, etc.

The "tentative method" of the American Society for Testing Materials uses potassium iodide, following the method of Diehl as modified by Topf. By taking the usual precautions against the loss of iodine this method gives consistent results in the analysis of dry red lead.

The method briefly stated is: 1 gram of red lead is rubbed to a paste with a few drops of water and a cool mixture of 30 grams of crystallized sodium acetate, 2.4 grams of potassium iodide and 10 cc. of water and 10 cc. of 50 per cent acetic acid are added and stirred until the red lead is dissolved, when 30 cc. of water and 5 grams of sodium acetate are added. The mixture is then cooled to room temperature and titrated immediately with N/10 sodium thiosulphate.

Stock Solution Saves Time

Much time may be saved and quite as accurate analyses obtained by using a stock solution of the mixture of sodium acetate, potassium iodide and acetic acid; and also of the water and sodium acetate. The stock solution containing the potassium iodide will of course in time decompose somewhat, but the error is too small to notice unless the solution has been kept a long time in a warm place and exposed to sunlight. A blank titration run in parallel on the stock solution, or the standardization of the sodium thiosulphate on a standard sample of red lead, will insure against error. Sabin in his "Technology of Paint and Varnish" gives a formula for making up the stock solution of sodium acetate and potassium iodide with 50 per cent acetic acid.

The writer has obtained excellent results by using a stock solution made up with ammonium acetate instead of sodium acetate; 600 grams of ammonium acetate and 60 grams of potassium iodide are made up to a volume of one liter by solution in 50 per cent acetic acid. This solution can be used in large excess without giving varying results, and it can be used on red lead to which has been added litharge, lead sulphate or zinc oxide or all three together.

To try this out a series of 0.5 gram samples of a standard sample of red lead were weighed out and several

were titrated in the usual way and several more after additions of varying portions of litharge, up to ½ gram, were added; several more after varying proportions of lead sulphate, up to ½ gram, were added; and several more after varying proportions of zinc oxide, up to ½ gram, were added. The red lead was found to be the same in all cases, showing that the added substances had no effect on the per cent of "true red lead" found.

A second similar set of analyses was run using sodium acetate stock solution made up according to Sabin. These analyses showed that the added substances have no effect. However, I found the per cent of "true red lead" consistently a very little higher than was obtained by the solution made up with ammonium acetate.

It is not necessary to wait until all the red lead dissolves when using the ammonium acetate solution; ½ gram of finely divided red lead will dissolve in 25 cc. of the stock solution in less than one minute by stirring cold. It is a good plan to run in the thiosulphate solution fast enough to keep the solution a pale yellow color while the red lead is dissolving. After the ½ gram of red lead is weighed out two minutes is all the time required for making the titration. It is a speedy and satisfactory estimation for dry red lead.

It does not give satisfactory results on red lead that has been mixed with oil. It seems impossible to free the red lead entirely from the oil. In ordinary cases of separation from oil there will be enough oil adherring to the red lead so that 2N nitric acid will dissolve the red lead completely.

Analytical Equations

The analytical equations that represent the reactions for the purpose of computation are:

(1) $Pb_3O_4 + 8KI + HC_2H_3O_2 + NaC_2H_3O_2 + XH_2O = 3PbI_2 + 2I + (n—8)\ HC_2H_3O_2 + 8KC_2H_3O_2 + NaC_2H_3O_2 + (X + 4)\ H_2O$.

(2) $2I + Na_2S_2O_3 = 2NaI + Na_2S_4O_6$. 2×126.92 parts iodine are equivalent to $(3 \times 207.2) + (4 \times 16)$ parts of red lead. Therefore the iodine value of the thiosulphate used multiplied by 2.6997 (practically 2.7) gives the amount of red lead in the sample used.

In applying the iodide method to peroxide of lead to see how closely it would check I used three different samples of peroxide from a manufacturer of analyzed chemicals for reagent and made a discovery that is worth recording. The three samples were in their original bottles with the labels and lot number of the manufacturer. The labels gave the amount of certain impurities, but only one gave the PbO_2 content. One sample contained less than fifty per cent PbO_2, one a little over sixty per cent PbO_2 and the third about ninety-five per cent PbO_2. This third sample gave the per cent of PbO_2 which checked quite closely with my analysis.

Methods Used as Checks

Toch in his "Technology of Paints" gives first place to the oxalic acid and permanganate of potassium volumetric method of Lux for estimating the "true red lead." The writer has used this method in check against the potassium iodide and sodium thiosulphate volumetric method on the same sample and mixtures and has found it to check as nearly as could be expected; in fact, my checks were so close as to throw doubt on my work, the iodide method giving 95.98 per cent and the oxalic acid method giving 96.01 per cent "true red lead," the highest variation in either case being eight points in the second decimal place.

The oxalic acid method is carried out as follows: 0.5 gram red lead is brought to the boiling temperature in 30 cc. of 2N nitric acid, and 25 cc. of N/5 oxalic acid are added and again brought to a boiling temperature and titrated with N/10 or N/5 potassium permanganate solution, to determine the excess of oxalic acid solution used.

It requires a little practice to know the end of the reaction, but this once learned, it is a very satisfactory method. The solutions are all easy to make and they keep well.

This method, like the iodide method, was not capable of giving consistent results in my hands on red lead after it was mixed with oil, no matter how carefully it was extracted to remove the oil.

The writer would modify the procedure so as to use both N/10 oxalic acid and N/10 permanganate whenever a high degree of accuracy is desired.

More Analytical Equations

The analytical equations for the purpose of computation are:

(1) $Pb_3O_4 + nHNO_3 + mH_2C_2O_4 + XH_2O = 3Pb(NO_3)_2 + (n—6)\ HNO_3 + (m—1)\ H_2C_2O_4 + 2CO_2 + (X + 4)\ H_2O$.

(2) $5H_2C_2O_4 + 2KMnO_4 + nHNO_3 + XH_2O = 2KNO_3 + 2Mn(NO_3)_2 + 10CO_2 + (N—6)\ HNO_3 + (X + 8)\ H_2O$.

685.6 Pb_3O_4 equivalent to 90.01 $H_2C_2O_4$. The value of oxalic acid consumed in the solution of the Pb_3O_4 multiplied by 7.62 gives the Pb_3O_4 in the sample used.

Holly in his "Analysis of Paint and Varnish Products" obtains the peroxide content of red lead by the method of Mannhardt, which is carried out in the main as follows: 1 gram of red lead is triturated with accurately weighed 1.176 grams of crystallized ammonium ferrous sulphate, then ten grains of ammonium chloride is added and the mixture moistened with a few drops of water and the whole rubbed together after which 20 cc. water and 20 cc. concentrated hydrochloric acid are added and then all is heated on the steam plate and titrated with 3N/10 potassium bichromate solution.

The writer was not favorably impressed with the manipulations in this method and considered a 3N/10 solution too concentrated, though concordant results were obtained on samples of dry red lead.

Modification for Daily Use

The following modification of this method for use where a number of samples are to be estimated daily works out very satisfactorily, giving consistent results, and being easily carried out, the most unsatisfactory thing about it being the use of an outside indicator.

Stock solution sufficient for the day's use of N/10 ammonium ferrous sulphate is made by dissolving 39.214 grams of the sulphate in 5N ammonium chloride to make a liter of solution.

The hydrochloric acid cannot be added to this solution without precipitation of the ammonium chloride. Therefore, the hydrochloric acid must be added after the red

lead has been mixed with the stock solution. To carry out the analysis with the stock solution 0.5 grams of red lead is moistened with a few drops of water and triturated, after which 25 cc. of stock solution and 25 cc. of concentrated hydrochloric acid are added. The mixture is stirred while heated until the red lead is decomposed, when it is titrated with N/10 potassium dichromate to determine the excess of ammonium ferrous sulphate used.

The analytical equations representing these reactions for the purpose of computation are:—

(1) $2\ (NH_4)_2SO_4\ FeSO_4\ 6H_2O + nHCl + Pb_3O_4 + m\ NH_4Cl + XH_2O = Fe_2(SO_4)_3 + (NH_4)_2SO_4 + 3PbCl_2 + (n - 8)\ HCl + (M + 2)\ NH_4Cl + (X + 16)\ H_2O.$

(2) $6\ (NH_4)_2SO_4\ FeSO_4\ 6H_2O + K_2Cr_2O_7 + NH_4Cl + XH_2O = 3Fe_2(SO_4)_3 + 12\ NH_4Cl + 2KCl + Cr_2(SO_4)_3 + (N - 14)\ HCl + (X + 43)\ H_2O.$

Each cubic centimeter of the ammonium ferrous sulphate consumed in bringing the red lead into solution is equivalent to 0.03428 gram of "true red lead."

"Rapid and Accurate" Volumetric Method

In the 1910 edition of "Stillman's Engineering Chemistry" a "rapid and accurate" volumetric method of determining "true red lead" in red lead by the use of stannous chloride as the reducing agent is described as carried out by Wainwright. It is repeated in the 1916 edition, indicating that it has been found satisfactory.

N/10 iodine solution and a solution of 14.1 grams stannous chloride in water to make one liter are used. The iodine value of the stannous chloride solution is formed under conditions identical with those used in the analysis.

In the analysis one gram of red lead is moistened with water and 25 cc. of the stannous chloride and 40 cc. of concentrated hydrochloric acid are run in, and boiled until the red lead is in solution, 100 cc. cold water added and further cooled and titrated with N/10 iodine solution to determine the excess of stannous chloride used.

Only Objection Is Overcome

The only objection to this method is the boiling and cooling of the solutions, and that the value of the stannous chloride must be found under practically identical conditions of boiling and cooling with those used in the analysis.

In order to do away with this difficulty N/10 stannous chloride in N/2 hydrochloric acid was used; 0.5 gram of red lead was moistened with water and triturated until the red lead is all very finely divided (this is the condition to success), 25 cc. N/10 stannous chloride run in and stirred, then 25 cc. concentrated hydrochloric acid are added and the whole stirred until all but some white particles is dissolved and then titrated cold with N/10 iodine. The end reaction is sharp, no heating is required and the results are consistent to a high degree of accuracy.

The method also worked well on peroxide of lead, it being only necessary to double the quantities of stannous chloride solution and hydrochloric acid.

Any one of the four methods is capable of consistent and practically accurate determination of "true red lead" in commercial red lead. The writer is inclined to the use of the stannous chloride method of Wainwright, with the modifications given in this paper.

Institute of Chemical Engineers

FOLLOWING is the program as officially announced for the eleventh annual meeting of the American Institute of Chemical Engineers to be held Jan. 15 to 18, 1919, in Chicago:

Wednesday, Jan. 15

9:00 A.M.—Registration of members at Congress Hotel.

9:30 A.M.—Address of Welcome — Mr. Leonard Busby, president Chicago surface lines.
Response by President Thompson.
Business Session.

11:00 A.M.—Address of President Thompson, "Chemical Industries Made Permanent."
Symposium on Maintenance and Preservation of Our Chemical Industries: Résumé of Conditions as They Exist at Present," M. Toch; "Recommendations of the Tariff Commission in Regard to Dyes and Coal Tar Chemicals," Dr. Grinell Jones of the U. S. Tariff Commission.

12:30 P.M.—Complimentary Luncheon at Congress Hotel. The Chicago members of the Institute will entertain all visiting members and guests.

2:00 P.M.—Symposium on Maintenance and Preservation of Our Chemical Industries, continued: Addresses by the following representatives of chemical manufacturers: Dr. Louis Matos of the National Aniline & Chemical Co., Robert Hilton of the Ault & Weiborg Co., Dr. A. A. L. Veillon of the Monsanto Chemical Co., O. Dill of Perth Amboy Chemical Works.
Discussion by representatives of other chemical industries.

8:00 P.M.—Reading of Papers: "Future of the Barium Industry," Wm. H. Rollin of the Rollin Chemical Co.; "Reconstruction Aspects of Some Chemical Industries of the United States," Dr. Edward Gudeman.

9:00 P.M.—Smoker.
Members of the Chicago section of the American Chemical Society will be the guests of the evening.

Thursday, Jan. 16

9:30 A.M.—Members will leave the Congress Hotel by auto at 9:30 A.M. for the Union Depot to take a special C. & A. train to Argo, Ill., to visit the plant of the Corn Products Refining Co. Luncheon will be served at the plant and the return trip will bring members back to the Congress Hotel at about 5 P.M.

8:00 P.M.—Joint meeting with local section of the American Chemical Society. "Present Status of Nitrogen Fixation," Lieut. Col. Alfred H. White. Illustrated by lantern slides.

Friday, Jan. 17

9:30 A.M.—Business Session.

10:30 A.M.—Reading of Papers: "Reinforced Concrete Tanks for Storing Ammonia Liquors, "F. W. Frerichs; "Some Wild Engineering I Have Known," David Wesson; "Belting for Power Transmission," Ernest D. Wilson.

12:00 M. —Complimentary Luncheon.

1:30 P.M.—Excursions.
Members and their guests will proceed by autos to the plant of the Lindsay Light Co. to inspect the preparation of rare earths and the manufacture of gas mantles.
Visit to the Underwriters' Laboratories of Chicago, where special demonstrations will be made.

7:00 P.M.—Subscription Dinner at Congress Hotel.

Saturday, Jan. 18

8:00 A.M.—Standard Oil Co., Whiting, Ind.

Census of Chemical Imports

THE census of chemical imports, which for the past ten months has been under preparation for the Bureau of Foreign and Domestic Commerce, has been completed. The necessity for this census was apparent immediately subsequent to the beginning of the European war. Its need for domestic chemical manufacturers was considered by the American Chemical Society in 1915 and a committee was designated by that society to procure it. After a conference by this committee with the Chief of the Bureau of Foreign and Domestic Commerce in November, 1917, the necessary steps were taken for the promulgation of the Census of Chemical Imports, stating therein quantity and value, and percentage by quantity of all products consumed in or produced by chemical and allied industries and imported into this country during the fiscal year 1913-14.

The census was commenced in March, 1918, and during most of the time since as many as twenty-four clerks have been employed in securing these voluminous statistics. The census shows in detail every chemical and allied chemical, drug and medicine imported into this country during the fiscal year July 1, 1913, to June 30, 1914, together with the quantity, value and percentage by the country of origin of each of these articles. Incorporated in the census is detailed information concerning 2500 articles having an entered value in excess of $100, and an alphabetical list of 4000 articles having an entered value less than $100. The total import value for the fiscal year 1913-14 of all the articles enumerated in the census is in excess of $268,000,000.

The principal classes of articles included in the census are: Chemicals, drugs, medicines, coal tar products, vegetable oils, animal oils, essential oils, perfumes, perfumery materials, cosmetics, toilet preparations, paints, pigments and varnishes, dyeing and tanning materials, fertilizers and soaps. Embodied in the census is information showing the distribution according to the countries of origin of these different articles considered by classes.

The Census of Chemical Imports will be published by the Government Printing Office by Feb. 1, and will then be ready for public distribution.

Production of Lead Pigment in the U. S.

According to statistics compiled in the United States Geological Survey, Department of the Interior, the total value of lead pigments of domestic manufacture sold in the United States in 1917 amounted to $36,663,923, as compared with $31,061,589 in 1916 and $24,614,006 in 1915. The quantities marketed, however, decreased steadily, as shown in the following table:

	1917		1916		1915	
Pigment	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value
White lead:						
In oil...	87,331	$17,608,967	96,041	$16,560,137	122,194	$15,879,835
Dry...	27,869	4,920,864	32,938	4,714,343	33,907	3,513,856
Red lead..	25,478	5,523,018	23,035	3,933,566	19,435	2,397,900
Litharge...	44,102	8,611,074	37,739	5,853,543	26,118	2,822,415
	184,780	$36,663,923	189,753	$31,061,589	201,654	$24,614,006

The abnormal conditions created by the war manifestly reacted strongly upon the lead-pigment industry. The high cost of everything that enters into the cost of manufacturing and marketing the product is reflected in the increased value.

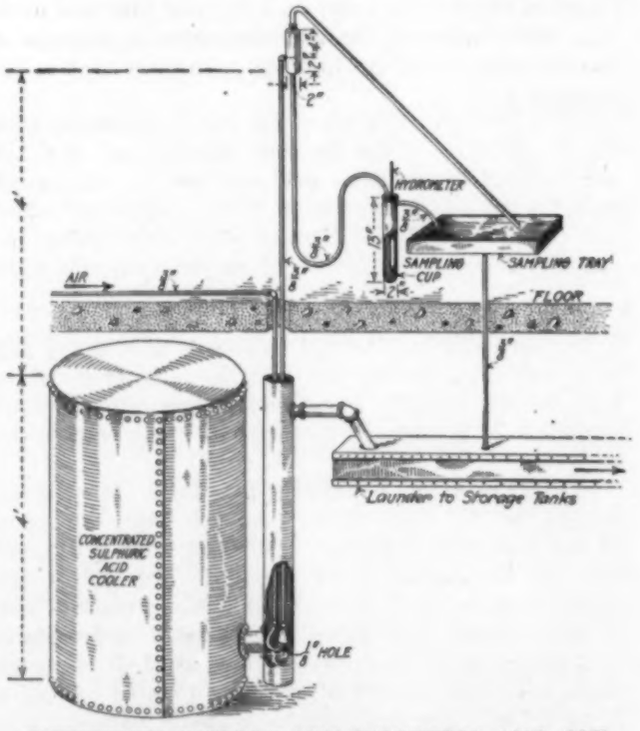
Continuous Sulphuric Acid Sampler

By S. A. Ionides

AT THE British Acetones plant in Toronto two 30-ton Chemical Construction Co. Gilchrist towers were installed to reconcentrate the sulphuric acid diluted in the regular operation there. The coolers for the concentrated acid were located between the towers below the main operating floor. Control of operation depended largely on the Baumé readings of the discharged concentrated acid, which were made each hour by dipping samples from the discharge pipe of the cooler, setting the dipper on a sampling tray and inserting a hydrometer. This operation was clumsy. Acid was apt to be splashed over the clothes of the operators, the mortality of the hydrometers was high and there was no inducement to take readings except at the regular time each hour, and with careless operating appreciable changes took place unnoticed between readings.

To remedy this situation, the simple continuous sampling device, illustrated here, was installed. It consisted essentially of a miniature air lift and as the acid was almost always below 60 deg. B., it was made entirely of lead.

The length of the upward discharge pipe from the cooler was 4 feet, and the acid had to be raised four feet further for convenient observation, which constituted a suitable ratio for an air lift. Three-eighths internal diameter lead pipe was used, that being the



CONTINUOUS SAMPLER FOR SULPHURIC ACID CONCENTRATOR

smallest size lead pipe readily available. The nozzle of the air pipe was reduced to one-eighth inch. The air pipe was connected to the air supply used for agitating the acid in the concentrators and it required only a minute flow of air to give a steady, small flow of acid up the lift and through the sampling cup. The separating head first installed allowed a little froth to come over with the air outlet, so the outlet pipe was bent

over as shown to discharge this into the sampling tray which was already installed. For the second tower the sampling head shown in the sketch was used, but the armistice was signed and the plant shut down before it was put into operation.

A slight froth formed on the surface of the sampling cup in the first installation, which at times tended to obscure the reading. To obviate this a trap was inserted between the separating head and the sampling cup in the second installation.

The important points in the construction of this apparatus were:

1. The relative diameters of the air nozzle and the riser pipe—one to three.
2. The position of the discharge pipe as near to the top of the sampling cup as possible for easy reading of the hydrometer.
3. The provision of some point at which the flow through the sampler could be observed to insure that a steady flow was passing through.

The advantages of this sampler were:

1. The ability to observe the Baumé of the discharged acid at any time.
2. The elimination of slashes of acid falling on the clothes of the operators.
3. The welcome and very marked reduction in the hydrometer casualty lists.

Patent was not applied for.

New Jersey Clay Workers Association Holds Meeting

THE fourth annual meeting of the New Jersey Clay Workers Association was held in the Queens Building, Rutgers College, New Brunswick, Dec. 17, with morning and afternoon sessions. President August Staudt, of the Perth Amboy Tile Works, Perth Amboy, presided at the morning meeting until the regular business session was concluded. New officers were elected for the ensuing year as follows: Charles Howell Cook, president Cook Pottery Co., Trenton, president; Abel Hansen, president Fords Porcelain Works, Perth Amboy, vice-president; and George H. Brown, director Department of Ceramics, Rutgers College, secretary and treasurer (re-elected). In the absence of Mr. Cook, Mr. Hansen presided for the remainder of the morning session.

Three interesting papers were presented in the forenoon, including "Some Defects in Terra Cotta," by D. F. Albery, Federal Terra Cotta Co., Woodbridge; "Sagger Mixtures," Professor George H. Brown, Rutgers College; and "The Effect of Some Fluxes in Porcelain," by F. H. Riddle, Bureau of Standards, Pittsburgh.

Professor Brown's paper covered the subject of sagger mixtures with great detail, embracing the character of sagger failures, properties of saggers, mechanical strength, hair cracks, resistance to deformation, as well as raw materials and composition. The paper was illustrated with interesting and illuminating charts.

Mr. Riddle's paper was illustrated with lantern slides, while a number of test specimens of porcelain were shown. The speaker made reference to the effect of such well-known fluxes as feldspar, magnesium oxide, calcium and barium. The clays used in the tests were from Florida, Delaware, North Carolina and Georgia; American clays exclusively were employed. The paper gave a number of interesting sidelights on the subject.

Following a recess for luncheon, the meeting reassembled, with President-elect Cook in the chair. Henry Kreisinger, Fuel Section of the United States Bureau of Mines, Pittsburgh, spoke on "Fuel Combustion"; Professor Carl B. Harrop, Department of Ceramic Engineering, Ohio State University, Columbus, gave an interesting address on "Future Kiln Developments," while a representative of the Philadelphia Textile Machinery Co., Philadelphia, spoke on the subject of "Solving One of the Clay Manufacturer's Greatest Problems," covering in detail the utility and value of the well-known Proctor drier manufactured by this company.

Professor Harrop's paper was an exhaustive study of car tunnel kilns, tracing the manufacture of different types of kilns of this style to the present time. He pointed out that the most successful tunnel kilns now in use were the American Dressler and the Didier-March, but that still much was desired in the way of greater perfection and efficiency. In tracing the employment of the tunnel kiln, he pointed out that after considerable investigation he had learned that such kilns had been developed as follows, some few in the list now having been practically forgotten:

Type	Number in Use
Anderson, 1891	1
Shaw, 1909	2
Didier-March, 1910	10
Dressler, 1915	19
Owens, 1916	11
Zwermann	1
Powell	1
Harbison-Walker	1
Total	46

This tabulation shows the extent of the use of car tunnel kilns in this country. The speaker urged greater simplicity in future kiln development, holding that there were great possibilities for the adaptation of an efficient kiln which allowed operation without the existing complications.

New Jersey Chemical Society

ON MONDAY evening, Dec. 9, 1918, the newly elected officers of the New Jersey Chemical Society assumed office. They are: President, Carleton Ellis, New Jersey Laboratories, Montclair, N. J.; vice-president, Frederic Dannerth, Consulting Chemist, Newark, N. J.; secretary, Herbert C. Cawley, the Harrison-Dupont Works, Newark, N. J.; treasurer, D. K. Howard; directors, R. P. Calvert, H. B. Baldwin, D. R. Hodgdon, W. A. Lucas, J. M. Reilly and W. G. Wright.

The scientific paper of the evening was presented by Dr. Alexander Smith of Columbia University, who spoke on "Some Common Errors in Chemical Text Books." The popular address was delivered by Mr. James M. Reilly, general secretary of the Board of Trade in Newark. He chose for his subject: "The Recent Developments of Chemical Industry in the State of New Jersey." The speaker referred to the tremendous growth of the plants which make chemicals for many different industrial processes. In this sense, the New Jersey industries are to a large extent "key industries." These include inorganic acids and alkalis, oil products, dyes and rubber-covered wire. Without them, the existence of many other general industries would be threatened. The

special guest of the evening was Lieut. J. V. Meigs, of the Edgewood Arsenal, Maryland, who spoke briefly of the production of poison gases for chemical warfare.

For Monday evening, Jan. 13, 1919, the Society has planned a "Rubber Night." An informal dinner will be held at the Achtel-Stetter Restaurant at 6 p.m. and the session will be held at the Newark Technical School at 8 p.m. New members will be admitted at that time.

The scientific paper will be by Mr. G. D. Kratz of Cuyahoga Falls, Ohio, on "The Application of the Principles of Catalysis in the Manufacture of Rubber Goods" (a study of accelerators used in vulcanization).

The popular paper will be by Dr. Frederic Dannerth of Newark, N. J., on "Some American Substitutes for Rubber." There will be an exhibit of rubber goods and substitutes for rubber in the large auditorium of the school. The Rubber Association of America will hold its annual meeting and banquet in New York City in the same week, so that a large attendance of rubber experts from other States is expected at the January meeting.

The New Jersey Chemical Society was organized with the idea of bringing together the chemists of New Jersey, co-operating with various educational activities in northern New Jersey, and of bringing the chemical profession into prominence in that part of the State, as well as the general object of promoting discussion among the chemists. The secretary will be glad to receive applications for membership. Address H. C. Cawley, secretary, E. I. du Pont de Nemours & Co., 256 Vanderpool Street, Newark, N. J.

Meeting of Manufacturers' Council of New Jersey

CHEMICAL and affiliated interests were strongly represented at the special meeting of the Manufacturers' Council of the State of New Jersey, held at the Robert Treat Hotel, Newark, on Dec. 11. This convention, called for readjustment purposes, was the first gathering of its kind held by any state organization, and brought together about 250 delegates from all parts of the state. The meeting was called to order by Warren C. King, president of the King Chemical Co. and president of the Council, at 10:30 a.m. He told of the general purposes of the meeting and the aims to be accomplished and pointed out that the primary topics before the convention were labor, cancellation of war contracts, plant readjustment, compensation insurance and factory operation on a pre-war basis. He urged a consolidation of the different manufacturing interests of the state in a spirit of co-operation to bring about utmost co-ordination and thrift for individual and collective benefit.

In this connection, he urged the establishment of a State Industrial Commission to formulate definite plans for immediate action, devising a comprehensive program for concerted effort, and at the same time place itself in position to handle such individual problems as might arise. This recommendation was approved by the delegates assembled in a resolution covering the formation of a commission to be composed of five members each from manufacturing, financial, agricultural and public utility interests, as well as five members to represent labor engaged in manufacturing and public utility work, respectively, making a total of thirty members on the committee. The personnel of the State Industrial Commission will be announced at an early date.

The subject of labor and wage scales as now operative occupied considerable discussion at the different sessions. It was pointed out that overtime must stop and the standard working day be placed into effect. Representatives of labor present at the meeting expressed full accord with these sentiments. A resolution was adopted reading, "It is the sense of this convention that there should be no radical reduction in the present scale of wages until the purchasing power of the dollar increases and in any event wages should be the last thing cut in any readjustment." Addresses on the subject of labor and wages were made by Arthur A. Quinn and Henry F. Hilfers, president and secretary, respectively, of the New Jersey State Federation of Labor.

Important addresses were made at the morning session by John D. Everett, former president New Jersey State Bankers' Association; Dr. J. G. Lipman, dean and director New Jersey Agricultural Experiment Stations, and Myrza Ali Kula Khan, Persian Minister to the United States. The afternoon was devoted to group meetings of manufacturers, banking, agricultural and labor interests, with a reassembling of the full convention for the adoption of final resolutions before the close of the day.

A banquet was given in the evening in the ballroom of the hotel, Mr. King acting as toastmaster. Among the speakers were W. H. Besler, president of the Central Railroad of New Jersey; Dr. W. H. S. Demarest, president Rutgers College, and Dr. Alexander C. Humphreys, president Stevens Institute of Technology. Col. Austen Colgate, first vice-president of the Council, who presided at the afternoon business session, was expected to address the evening gathering, but was unable to be present.

The Council has a membership of over 120 prominent concerns in the state at the present time. Among the chemical and affiliated industries now represented in the organization are: Central Dyestuff & Chemical Co., Newark; United States Metals Refining Co., Chrome; Ajax Rubber Co., Trenton; American Color Mfg. Co., Passaic; Barnes Chemical Works, Paterson; Yatman Rubber Co., Newark; United & Globe Rubber Mfg. Co., Trenton; Star Porcelain Co., Trenton; E. R. Squibb & Sons, New Brunswick, chemicals; Raritan Copper Works, Perth Amboy; Paterson Parchment Paper Co., Paterson; King Chemical Co., Bound Brook; American Oil & Supply Co., Newark; Anderson Chemical Co., Wallington; Armstrong Cork Co., Camden; J. T. Baker Chemical Co., Phillipsburg; Braender Rubber & Tire Co., Rutherford; Bulls Ferry Chemical Co., Edgewater; Columbus Crystal Co., Newark; Condensite Co. of America, Bloomfield; Charles Cooper & Co., New York, chemicals; Cumberland Glass Mfg. Co., Bridgeton; Delion Tire & Rubber Co., Trenton; Dexter Metal Mfg. Co., Camden; Didier-March Co., Perth Amboy; E. I. du Pont de Nemours & Co., Haskell; Fords Porcelain Works, Perth Amboy; Gaynor Glass Co., Salem; Howe Rubber Co., New Brunswick; R. M. Hollingshead Co., Camden, chemicals; and J. L. Mott Co., Trenton.

Personal

PROF. FRED W. ASHTON has been granted a leave of absence by the University of the Philippines and has taken over new duties as carbonization supervisor with the Chemical Warfare Service at Manila, P. I.

MR. VERNE W. AUBEL, who recently returned from blast furnace work in Australia and New Zealand, has been appointed assistant superintendent of blast furnaces at the Clairton, Pa., plant of the Carnegie Steel Co.

DR. SERGIO BAGNARA has resigned as metallurgical engineer of the Ordnance Department, U. S. A., and will locate in New York temporarily.

MR. E. H. BEDELL, who left CHEMICAL & METALLURGICAL ENGINEERING on Aug. 10 to serve in the Ordnance Department, returned on Jan. 1 to resume his former duties as Eastern Representative in the Advertising Department.

DR. GEORGE W. COGGESHALL, who has been serving with the Emergency Fleet Corporation, has resigned, and will return to his duties as a member of the staff of the Institute of Industrial Research, Washington, D. C. Dr. Coggeshall specialized during the war on concrete-ship construction, including oilproofing and waterproofing.

DR ALLERTON S. CUSHMAN has just received his honorable discharge as Lieutenant-Colonel in the Ordnance Department, U. S. A. For eighteen months he had charge of the research and chemical laboratories, including the explosives activities, at Frankford Arsenal, Pa., where he was engaged principally on ammunition and metallurgical problems. Dr. Cushman now returns to his former professional activities as head of the Institute of Industrial Research, Washington, D. C.

MR. C. T. HENDERSON has resigned as chief engineer of the Submarine Boat Corporation, Port Newark Terminal, Newark, N. J., and has accepted a similar position with the Hercules Engineering Corporation, 501 Fifth Avenue, New York. He also acts as president of the Electrolytic Engineering Corporation at the same address.

MR. ARTHUR J. HOSKIN, consulting engineer of Denver, Colo., has returned after a three-months' stay in Dillon, Mont., where he was engaged in installing an oil-shale plant.

MR. S. A. IONIDES has resigned from the British Acetones Toronto, Ltd., and intends to open up his office in Denver again as a metallurgical and chemical engineer.

MR. J. J. MCKEE, formerly New York manager of the C. A. Dunham Co. of Marshalltown, Ia., has accepted a position with the Machinery Utilities Co., 501 Fifth Avenue, New York.

MR. FRANK PURNELL, assistant to Mr. J. REPLOGLE, director of steel supply at Washington, has returned to the sales department of the Youngstown Sheet & Tube Co., Youngstown, O. Mr. Purnell was called to Washington fifteen months ago and has served in various capacities in the steel section.

MR. P. B. SADTLER, vice-president of the Swenson Evaporator Co., Chicago, Ill., who has been operated on for appendicitis, expects to return to his duties shortly after the first of the year.

MR. R. B. SAUSEN has become identified with the Star Brass Works of Chicago, Ill., and engaged in sales promotion and research work of spray cooling equipment. He was formerly district manager of the Chicago office for the Schutte & Koerting Co., of Philadelphia, Pa.

MR. HORACE V. WINCHELL has been nominated for president of the American Institute of Mining Engineers.

MR. O. WISER, for several years the assistant superintendent of the Hurley (N. M.) mill of the Chino Copper Company, has recently resigned to become president of the Republic Mining & Milling Co., with offices at Hurley and operations at Hanover. Mr. O. F. RISER is now assistant superintendent of the Chino mill.

Obituary

MR. WILLIAM GARRIGUE died of pneumonia at Toronto, Ont., Oct. 2, 1918. By his death the chemical engineering profession and the chemical industry suffered a distinct loss. Mr. Garrigue had particularly identified himself with the soap and glycerine industry and the equipment

MR. WILLIAM GARRIGUE

designed and built by his firm, William Garrigue & Co., is in use by firms throughout this line of manufacture. Mr. Garrigue was born at Copenhagen, Denmark, in 1872. He came to the United States when a child with his parents, who settled in New York City. His father, Dr. Henry J. Garrigue, was a prominent physician and writer on medical subjects. Mr. Garrigue was educated in the public schools of New York, later taking special courses at Columbia University in chemistry and studying chemistry under a private tutor in the laboratory of one of the best analytical chemists of that day in New York. After completing his education Mr. Garrigue's love of adventure and outdoor life led him to the Far West, where he soon became interested in mining. From there he went to Pittsburgh and opened a consulting and testing laboratory. About this time he became connected with the firm of W. & H. Walker, Herr's Island, Pittsburgh, who were interested in greases, oils, soaps, etc. Mr. Garrigue soon established himself as an expert in this field, which from that time on formed his sole line of activity. He acted as consulting and designing engineer for soap and glycerine equipment, maintaining offices in Detroit, Louisville, New Orleans and finally in New York and Chicago. Mr. Garrigue's principal contributions to industrial chemistry were the following: 1. The principle of double effect glycerine distillation. This was a process for distilling glycerine which has largely taken the place of the Jobbins still, previously the leading equipment. The vapor from the concentrator is used as the injected live steam for the still. This does away with using fresh superheated steam and contributes greatly to the economy of the operation. 2. Separation of trimethyleneglycol from glycerine. 3. The recovery of dynamite glycerine from cotton-seed soap stock spent lyes. 4. Reversible double effect evaporation for spent soap lye. 5. The combined evaporation of caustic soda, lye and spent soap lye in triple effect. 6. Direct autoclaving of cotton-seed soap stock before distilling fatty acids. Also decided improvements in the construction of vacuum evaporators and solvent extractors. In addition to his work in the soap and glycerine industry, Mr. Garrigue designed and built

an interesting plant for the recovery of potash from molasses distillery slop at Harvey, La., and also a complete garbage reduction plant for the city of Erie, Pa. Mr. Garrigue was a member of the American Chemical Society, the American Institute of Chemical Engineers, the Chemists' Club of New York, the New Orleans Country Club, and the Southern Yacht Club, New Orleans. His interests were by no means limited to his profession. He was one of those men who regard education as a process that should last throughout a man's life. Regardless of whether science, literature, politics or art was the subject of the conversation, he would have some idea or some new point of view to contribute that would be interesting and helpful. The feeling of loss on the part of those who knew him intimately occasioned by his sudden and unexpected death is a very real one.

MR. WILLIAM H. STUBBLEBINE, inventor of the Stubblebine furnace, died at his home in Allentown, Pa., Dec. 6, aged 78 years. He was born in Reading, Pa., saw service in the Civil War, and on his retirement from the army in 1863 located at Bethlehem, Pa. He became one of the associates of the late John Fritz in developing the activities of the Bethlehem Iron Co., now the Bethlehem Steel Co. In 1875 he was appointed superintendent of the merchant department and in 1907 he retired. He leaves a son, W. A. Stubblebine, and two daughters.

MR. EMERSON H. STRICKLER, manager of the inorganic research department of the General Chemical Co., died on Nov. 22. Mr. Strickler's most recent and conspicuous achievement was the conception and development of Ryzon baking powder.

DR. HARRY PERCIVAL CORLISS, until recently an Industrial Fellow in the Mellon Institute of Industrial Research, University of Pittsburgh, died at Ray, Arizona, on Nov. 16, of pneumonia following influenza, as mentioned in our Dec. 15 issue. Funeral services were held on Dec. 23 at the First Congregational Church of Wolfeboro, N. H., where his parents, Charles H. and Mary A. Corliss, are now living. He is survived by his wife, Marion Pilkey Corliss, and a sister, Mrs. Donna Nickerson. Dr. Corliss was born at Thornton, N. H., Oct. 21, 1886. He attended Brewster Academy at Wolfeboro, and was graduated in 1910 from New Hampshire State College with the degree of Bachelor of Science in Chemical Engineering. He then continued the study of chemistry at the University of Toronto, specializing in physical and organic chemistry. In July, 1912, he accepted a position as Industrial Fellow at the Mellon Institute, and in 1913 received the degree of Doctor of Philosophy from the University of Pittsburgh. Dr. Corliss' work at the Mellon Institute extended over a period of five years, during most of which time he was engaged in physical, chemical and metallurgical research. This research resulted in the development of several important improvements upon the flotation process for the recovery of minerals. Perhaps his greatest contribution to this industry was the discovery of alpha-naphthylamine as a flotation agent. It is too early as yet to estimate the full value of this discovery, but the excellent practical results already following its use warrant the belief that the work of Dr. Corliss will eventually be recognized as being of first importance in this field. In July, 1917, he accepted a position as chemical and metallurgical engineer with the Metals Recovery Co. in order to initiate the large scale application of his discoveries in the flotation mills of the Southwest. In this work he was uniformly successful and was rapidly making for himself an enviable reputation as a metallurgical engineer when death called him. From his boyhood up, Dr. Corliss' associates recognized in him the qualities of marked intellectual brilliancy and very real moral worth. All through his student days the highest scholastic honors came to him without conscious effort on his part because he loved the study of chemistry in all its branches. He brought the same qualities of mind and spirit to his research work at the Mellon Institute and to its extension in the wider fields of industrial application. His many friends will feel that by his death the world was deprived of a life which held unusual possibilities for useful work and high accomplishment.

MR. HENRY EDWARD RANDALL, JR., died on Oct. 21, aged 25 years. His death occurred after an illness of one week at Montreal General Hospital as a result of pneumonia, following an attack of influenza. Mr. Randall was a native of Vermont, was graduated at Massachusetts Institute of Technology in 1913 and immediately accepted a position with the Shawinigan Water and Power Co. of Canada, with which company he was affiliated for five years in various branches of their system—with the North Shore Power Co. of Three Rivers, Quebec, as power sales engineer and assistant to the vice-president in Montreal, and as

HENRY EDWARD RANDALL, JR.

general manager of subsidiary companies. He possessed high ideals of serving his country in an industrial way during the war and was one of the most successful captains in the Montreal Victory Loan drive of November, 1917. On Oct. 1, 1918, Mr. Randall became general manager of the Ludlum Electric Furnace Corporation and removed to New York. He was also consulting engineer for the Canadian Ferro-Alloys Co. in Shawinigan Falls, Quebec. Mr. Randall was a member of the American Illuminating Electrical Engineering Society, American Electrochemical Society, American Foundrymen's Association, Canadian Society of Civil Engineers, Canadian Electrical Association, Engineers' Club of Montreal, Marmier Club of Canada and Phi Delta Theta Fraternity.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, Dec. 28.—Prices are declining. In general consumers are not adding to stocks, with a result that all markets are dull at present. Major transactions are expected after New Year's.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton lots; and $666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—Market continues to be dull with prices as low as 7¼c. per lb.

Lead:—In common with the general trend, lead is declining in price, East St. Louis being $114 per ton. Small sales are being made at 6c. per lb. in New York; 5¼c. appears to be the probable objective.

Tin:—The tin market is not under domestic control and prices are generally dull at 72¼c. per lb. Minor sales at 71c. have been reported, but the U. S. Steel Products Company has purchased 10,000 tons at 72¼c., so that lower prices are not probable.

Copper:—The producers have agreed on a price of $460 per ton for carload lots. Large foreign sales are predicted, as this is believed to be a permanent price.

Copper sheets, hot rolled	lb.	$0.36 —	$0.37½
Copper sheets, cold rolled	lb.	.37 —	.38½
Copper bottoms	lb.	.44 —	.45½
Copper rods	lb.	.36 —	.37
Copper wire	lb.	.29½—	.....
High brass wire	lb.	.28½—	.29½
High brass sheets	lb.	.28½—	.29½
High brass rods	lb.	.26½—	.28½
Low brass wire	lb.	.32½—	.34½
Low brass sheets	lb.	.32½—	.34½
Low brass rods	lb.	.33½—	.35½
Brazed brass tubing	lb.	.37 —	.39
Brazed bronze tubing	lb.	.42½—	.44½
Seamless copper tubing	lb.	.41 —	.43
Seamless bronze tubing	lb	.45 —	.46
Seamless brass tubing	lb.	.37½—	.39½
Bronze (gold) powder	lb.	1.00 —	1.75

Tungsten:—The buyers of tungsten are decidedly cautious, though there is not likely to be any unlooked-for changes. Prices are nominal, scheelite bringing $25, wolframite, $20 to $21, with no sales of low grade reported.

Zinc:—Consumers are drawing on their stocks, making a dull market. Spot New York is quoted at $166 per ton; East St. Louis, December, $160 per ton; January, $151; February, $149, and March, $148.

OTHER METALS

Bismuth	lb.	$3.50—	$3.65
Cadmium	lb.	1.50—	.....
Cobalt	lb.	2.50—	3.50
Magnesium	lb.	1.75—	2.10
Mercury	75 lb.	115.00—	.....
Mercury	lb.	1.95—	.....
Nickel	lb.	.40—	.43
Tungsten	lb.	34.00—	.....
Iridium	oz.	175.00—	.....
Palladium	oz.	135.00—	.....
Platinum	oz.	105.00—	108.00
Silver	oz.	1.01½—	.....

The Iron and Steel Market

The theory propounded in our last review, that iron and steel prices as established by Government control would be continued for an indefinite period because there was more to be gained by maintaining prices than by cutting them, has been borne out in substance though not in form Steel prices have been reduced, and for this our last review had this saving observation: "Of course there is the bare possibility of a new and lower level of prices being put out, perhaps under Steel Corporation leadership, in hope of the market being stabilized upon it, but that is extremely improbable." It was due to Judge Gary's courage and influence that what seemed extremely improbable actually occurred. As the machinery of Government price fixing had not been scrapped, the iron and steel industry had an opportunity to get together and discuss what recommendations it would make to the War Industries Board with respect to prices that might be named for the first quarter of the new year. It is stated that when the meeting opened about nine-tenths of those present were opposed to recommending that reductions be made. Through Judge Gary's leadership the meeting was led to passing, practically unanimously, a resolution empowering the general committee of the American Iron and Steel Institute to recommend price reductions. A definite schedule, it appears, had been formulated, but it was not presented at the meeting. When the committee met the War Industries Board according to an arrangement that had been made long before, there were mutual felicitations appropriate to the ending of the war, and then Judge Gary undertook to read the prepared memorandum of suggested price reductions. The chairman of the board's price fixing committee at once stated that it would not be desirable to have the suggestions read into the minutes and the meeting promptly adjourned. The statement was then given to the press.

Readjustment to a Peace-Time Basis

The object of the suggested reductions was to take a step in the direction of readjusting the iron and steel price structure to a peace-time basis, to set an example to the sellers of other commodities used in construction work so as to facilitate the resumption of construction operations and to furnish a basis for the adjustment of prices under such contracts for the sale of steel as otherwise would hardly be specified against. By making slight reductions the market would be stabilized and if the new prices were not low enough for the indefinite future declines would at any rate be postponed. The steel makers promptly adopted the suggested reductions for their part, but the blast furnaces have not adopted the suggestion of a $3 reduction in pig iron. They maintain that they are well sold up, say as to 90 per cent of their prospective make to July 1, and on contracts that can be enforced. Many steel contracts, on the other hand, are in accordance with the trade practice subject merely to the desire of the buyer to specify under them.

Unfinished steel is reduced $4 a ton to $43.50 for billets, $47 for sheet bars and small billets and $46 for slabs, rods being left at $57. Reductions in finished steel, in dollars per net ton to cents per pound are: Plates, $5 to 3c.; shapes, $4 to 2.80c.; bars, $4 to 2.70c.; blue annealed sheets 10 gage, $7 to 3.90c.; black sheets, 28 gage, $6 to 4.70c.; galvanized sheets, 28 gage, $4 to 6.05c.; steel pipe, $6 to a card with 54 per cent basing discount. Wire products are not reduced. The schedule aims to take into account production costs in the different lines. The suggested reduction in pig iron is $3, which would make basic prices, f.o.b. furnace or f.o.b. basing point in certain cases, $30 for basic, $32.20 for bessemer and $31 for No. 2 foundry, 1.75 to 2.25 per cent silicon.

Pig Iron Prices

Apart from the argument that their product is already well sold up on firm contract, the blast furnaces probably feel that reduction should be avoided at this time because a general reduction would not promise a stable market to the same extent as would exist in steel, since the pig iron market would still have some abnormal alignments to smooth out. The control prices for the different districts do not bear the relations to each other that usually obtain. Birmingham is as high as Valley, Eastern Pennsylvania has a Pittsburgh basing, and so on. These relations will not continue indefinitely.

War orders are practically all canceled by this time, and requirements on behalf of shipbuilding and the railroads are on a reduced basis, in the case of shipbuilding because there is an accumulation of steel and in the case of the railroads because the matter of control and ownership of the railroads for the future is not determined, this preventing the carrying out of any definite policy. The demand for steel that accumulated during the period of delivery control is being worked out. In the case of sheets this is quite heavy, automobile builders and various metal working shops being ready and anxious for deliveries. In other lines there is some accumulation. No new demand is originating from ultimate consumers, particularly from investors. The need may exist for more factories, bridges and the like, but it is too soon for it to be expressed. Lighter and lighter operation of the steel industry as a whole is promised until regular investment buying becomes a factor. Steel production may drop to 80, 70 or possibly even 60 per cent of capacity in from one to three months.

Safety for Steel User Demanded

The revival of demand for steel on a broad scale commensurate with the capacity of the industry hinges chiefly upon the matter of stability and cost of investments. The investor in works of permanent construction must be assured of safety for his investment—no bolshevism—and of there being no saving by postponing action. The cost of producing steel is high and may remain nearly as high as now. The cost of putting steel into employment is still more abnormal, by reason of high costs of other construction material, of high wage rates and labor scarcity and of very indifferent performance by labor. For a full demand for steel to be expressed there is more need for reduction in the cost of consuming steel than for reduction in the cost of producing steel. Thus the steel producer has not the power to make conditions favorable to heavy production and consumption of steel, but must bide his time, meanwhile endeavoring to squeeze out of the contract business on books as much tonnage as possible and at as favorable prices as possible, putting his works in good shape and weeding out the worst slackers in the working forces.

Chemical Market

HEAVY CHEMICALS:—Conditions surrounding this market have developed into an exceptionally unsettled situation. Many of the buyers were seemingly of the impression that shortly after the armistice signing immediate resumption of peace conditions would set in, but this having not taken place has apparently created a very quiet market, whereby the trading that is passing is only for pressing needs, with no disposition on the part of buyers to purchase ahead, while also great anxiety is noticeable among dealers relative to the final condition, after the readjustment takes place, and which is now under way. However, during the interval many price changes are being effected, and almost in every instance having a downward tendency. Second hands, who are apparently anticipating further reductions, are selling below the manufacturers' prices.

Caustic Soda:—There has been a continued indifferent attitude on the part of buyers, and the market during the latter part of the week developed a rather weak position, with material from the warehouses declining from $3.90 to $3.80 per hundred pounds. The trade is looking forward to the day when steamer space will be more free, and many prominent authorities have this item noted for a large volume of foreign business. Second hands are offering the product over next year at price concessions, while producers' quotations are unchanged at $3.30 to $3.40 basis 60% works.

Soda Ash:—Demand for this product has been comparatively light, although factors are also looking forward with confidence to an improved export movement, but any opinion is more or less of a speculative nature owing to the uncertainty surrounding the freight situation. Bag material in New York was offered at from 2c. to 2¼c. per pound, while light ash in barrels was available from the warehouse at $2.40 and double bags from middle western shipping points were quoted at $2.40 to $2.50 per hundred pounds.

Bleaching Powder:—Trading of a minor character continues to feature this market, but producers are apparently in a position to maintain their prices, at the recent decline. The material in domestic drums was quoted at from 2c. to 2¼c. per pound, while that in export drums was held at 3¼c. to 3¾c. per pound F.A.S.

Bichromate of Soda:—No material improvement can be traced in the consuming demand for this product. Fair quantities of the material was available in the resale market at from 17c. to 17½c. per pound, while first hands were quoting at from 17½c. to 18c. for goods from the warehouses.

Bichromate of Potash:—Trading in any appreciable quantity is not in evidence; however, stocks on the spot are adequate for the current call. Dealers continue to quote at from 38c. to 40c., according to quantity.

Hyposulphite of Soda:—The precipitated product, which is the most preferable, is none too free in supply, although consuming requirements are not strong and the situation on the whole is well met. Offerings of the product are made at 3¼c. per pound, but some business has passed below this figure.

Bicarbonate of Soda:—Producers report a fairly active call for this material on contract, but the recent activity in the market for spot goods has eased up to a very noticeable extent, due to the fact that certain buyers who were taking considerable of the material from the market have bought up to their requirements. Barrel material is quoted at 3¼c. per pound, while that in kegs is held at 3½c. per pound.

Permanganate of Potash:—Second hands are keeping spot prices for this commodity rather unsettled, while first hands are reporting a rather steady market at $1.50 for the U.S.P. product. The technical grade is subject to no important call and is quoted at from $1.25 to $1.30.

Carbonate of Magnesia:—The market remains quietly firm, with no price changes noted, and trading is of a routine nature, with no interest otherwise noted. Standard brands in bags are offered at 12½c. to 14c. per pound, while the product in barrels is quoted at 16c. to 18c. per pound.

COAL TAR PRODUCTS:—The quietness that has been in evidence for some time continues and has had its effect on the market, with many of the items subject to a decline. Buyers are apparently of the opinion that further reductions in prices will develop, and purchasing is merely for immediate needs. This condition, in addition to the shading of prices, featured the market during the interval. Among the crudes, benzol prices were firmly maintained by the producers, while phenol has been subject to a sharp decline, with frequent cheap offerings appearing in the resale market. Toluol, which is now in liberal supply on the spot, has also gone down with a swoop. There are many of the intermediates which are still in scant supply, but owing to the seasonal dullness the situation on the whole is well met.

Benzol:—Prices for this commodity are firmly maintained despite the quietness that is prevailing, with no indication of any material changes developing at the moment. The present demand is of a routine nature, with no other interest noted.

Phenol:—An unsettled condition has developed in this market due to the extensive stocks reported to be on hand in the various directions, and producers have reduced their prices 10c., while offerings in the resale market are frequently heard at from 5c. to 10c. below this figure.

Metatoluolenediamine:—The commodity is another of the items that has been affected through the recent decline in toluol and factors in this line are now offering at from 10c. to 15c. below the recent quotations, with very little interest shown on the part of buyers, who seemingly are anticipating a further decline.

Diethylaniline:—The slack that has also appeared in this market has brought about an easier situation so far as stocks are concerned and prices in some instances have declined from 25c. to 50c., while other directions are not disposed to alter their recent quotations.

Benzidine:—Local interest in the product is without special feature and the sulphate seems to be entirely neglected, while the only interest noted at the moment is for the base product for export purposes. Stocks on the whole are in sufficient quantities to take care of additional business, but prices are quotably unchanged.

Aniline Salt:—This item of the coal tar products has been subject to no important call during the past two weeks, with anxious weak holders playing havoc with the market on several occasions. Producers, however, have not changed their quotations since the recent decline.

Benzoic Acid:—Under liberal offerings and the continued quiet demand the market has apparently developed a rather weak position and the trading that is passing is transacted at some low levels, although producers have not materially changed their prices.

Alpha Naphthol:—The market remains quietly firm, with the demand for consumers' use being of a routine nature and prices for both the refined and crude grades being firmly maintained by producers.

Metaphenylenediamine:—The item is neither in pronounced supply nor demand and prices are fairly steady.

Metanitraniline:—Stocks of this product are adequate for the current call and dealers in the material are experiencing no difficulty in maintaining the present prices.

Dimethylaniline:—The consuming demand has eased up to a very noticeable extent and stocks therefore have accumulated, with the result that in some quarters price concessions were made, but this situation has originated no activity on the part of buyers.

Dinitrophenol:—There are now ample supplies on the spot of this product, which has been in scant supply for a long period, but quoted prices are subject to no material change.

Metanitroparatoluidin:—No important stocks of this product are noted and the spot situation is more or less nominal, with prices remaining firm.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DEC. 27, 1918

Acetic anhydride	lb.	1.60	—	1.85
Acetone	lb.	.25½	—	.25½
Acid, acetic, 28 per cent	cwt.	5.96	—	6.11
Acetic, 56 per cent	cwt.	10.76	—	10.87
Acetic, glacial, 99½ per cent, carboys	cwt.	19.00	—	19.20
Boric, crystals	lb.	.13½	—	.15
Citric, crystals	lb.	1.18	—	1.25
Hydrochloric, C. P	lb.	Nominal		
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.15	—	.16
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	Nominal		
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.38	—	.40
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.35	—	.40
Picric	lb.	.75	—	.85
Pyrogallic, resublimed	lb.	3.25	—	3.50
Sulphuric, 60 deg	ton	16.00	—	....
Sulphuric, 66 deg	ton	25.00	—	....
Sulphuric, oleum (Fuming), tank cars	ton	60.00	—	65.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.86	—	.95
Tungstic, per lb. of W	lb.	1.70	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91	—	....
Alcohol, wood, 95 per cent	gal.	.91½	—	.92
Alcohol, denatured, 180 proof	gal.	.68	—	.69
Alum, ammonia lump	lb.	.07½	—	.08½
Alum, chrome ammonium	lb.	.18	—	.19
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.09½	—	.10
Aluminium sulphate, technical	lb.	.02½	—	.02½
Aluminium sulphate, iron free	lb.	.04½	—	.04½
Ammonia aqua, 26 deg., carboys	lb.	.08½	—	.09
Ammonia, anhydrous	lb.	Nominal		
Ammonium carbonate	lb.	.12	—	.13
Ammonium nitrate	lb.	(Fixed Price)		.15
Ammonium, sulphate domestic	lb.	.07½	—	.08
Amyl acetate	gal.	5.30	—	5.35
Arsenic, white	lb.	.09½	—	.13
Arsenic, red	lb.	.65	—	.70
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	70.00	—	80.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½	—	.05
Barium nitrate	lb.	.12	—	.14
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.02	—	.03½
Borax, crystals, sacks	lb.	.08½	—	.08¾
Brimstone, crude	ton	65.00	—	70.00
Bromine, technical	lb.	.75	—	....
Calcium, acetate, crude	lb.	.04	—	.05
Calcium, carbide	lb.	.15	—	.17
Calcium chloride, 70-75 per cent, fused, lump	ton	22.00	—	24.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulphate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.08	—	.09
Carbon tetrachloride, drums	lb.	.16	—	.18
Carbonyl chloride (phosgene)	lb.	1.10	—	1.50
Caustic potash, 88-92 per cent	lb.	.67	—	.72
Caustic soda, 76 per cent	100 lb.	4.15	—	4.25
Chlorine, liquid	lb.	....	—	.07½
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.02½	—	.02½
Copper carbonate	lb.	.30	—	.31
Copper cyanide	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09½	—	.09½
Cream of tartar, crystals	lb.	.65	—	.70
Epsom salt, bags, U.S.P	100 lb.	3.10	—	3.40
Formaldehyde, 40 per cent	lb.	.16½	—	....
Glauber's salt	lb.	.02½	—	.03
Glycerine, bulk, C.P	lb.	.63	—	.65
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystals	lb.	.17	—	.17½
Lead arsenate (Paste)	lb.	.15	—	.18
Lead nitrate	lb.	Nominal		
Litharge, American	lb.	.12	—	.14
Lithium, carbonate	lb.	1.50	—	2.05
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see Carbonyl chloride)	lb.	1.10	—	1.50
Phosphorus, red	lb.	1.17	—	1.20
Phosphorus, yellow	lb.	1.20	—	1.25
Potassium bichromate	lb.	.40	—	.45
Potassium bromide granular	lb.	1.25	—	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38	—	.40
Potassium chlorate, crystals	lb.	.38	—	.40
Potassium cyanide, 98-99 per cent	lb.	.60	—	.70
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	300.00	—	350.00
Potassium nitrate	lb.	.27	—	.31
Potassium permanganate, U. S. P	lb.	1.50	—	1.75
Potassium prussiate, red	lb.	2.30	—	2.50
Potassium prussiate, yellow	lb.	.88	—	.95
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal		
Rochelle salts	lb.	.47	—	.48
Salammoniac, gray gran	lb.	.21	—	.22
Salammoniac, white gran	lb.	.18	—	.20
Sal soda	100 lb.	1.40	—	1.65
Salt cake	ton	18.00	—	20.00
Silver cyanide, based on market price of silver	oz.	....	—	....
Silver nitrate	oz.	.63½	—	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	2.05	—	....
Soda ash, 58 per cent, dense, flat	100 lb.	3.40	—	3.60
Sodium acetate	lb.	Nominal		
Sodium bicarbonate, domestic	lb.	.03½	—	.03½
Sodium bicarbonate, English	lb.	....	—	....
Sodium bichromate	lb.	.18½	—	.20
Sodium bisulphite, powd	lb.	.12	—	.14
Sodium chlorate	lb.	.25	—	.25½
Sodium cyanide	lb.	.30	—	.35
Sodium fluoride, commercial	lb.	.17	—	.18
Sodium hyposulphite	lb.	3.10	—	3.50
Sodium molybdate, per lb. of Mo	lb.	2.50	—	....
Sodium nitrate, 95 per cent	100 lb.	4.12	—	5.00
Sodium nitrite	lb.	.27	—	.30
Sodium peroxide	lb.	.35	—	.45
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.38	—	.39
Sodium silicate, liquid (60 deg.)	lb.	.03	—	.04
Sodium sulphide, 30 per cent, crystals	lb.	.02	—	.03
Sodium sulphide, 60 per cent, fused	100 lb.	.05	—	.06
Sodium sulphite	lb.	.05½	—	.06
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, drums	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.35	—	4.50
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	65.00	—	70.00
Tin bichloride, 50 deg	lb.	.28	—	.29
Tin oxide	lb.	Nominal		
Zinc carbonate	lb.	.18	—	.20
Zinc chloride	lb.	.15	—	.15½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.13½	—	.14
Zinc oxide, American process XX	lb.	.12	—	.12½
Zinc sulphate	lb.	.04½	—	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22	—	.27
Benzol, 90 per cent	gal.	.25	—	....
Toluol, in tank cars	gal.	.25	—	....
Toluol, in drums	gal.	.30	—	.35
Xylol, pure, water white	gal.	.45	—	.55
Solvent naphtha, water white	gal.	.18	—	.25
Solvent naphtha, crude, heavy	gal.	.12	—	.15
Creosote oil, 25 per cent	gal.	.45	—	.55
Dip oil, 20 per cent	gal.	.40	—	.45
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.50	—	1.60
Alpha naphthylamine	lb.	.55	—	.60
Aniline oil, drums extra	lb.	.27	—	.30
Aniline salts	lb.	.42	—	.43
Anthracene, 80 per cent	lb.	Nominal		
Benzaldehyde (f.f.c.)	lb.	4.25	—	4.50
Benzidine, base	lb.	1.65	—	1.75
Benzidine, sulphate	lb.	1.35	—	1.40
Benzoic acid, U. S. P	lb.	2.25	—	2.50
Benzoate of Soda, U. S. P	lb.	2.15	—	2.25
Benzyl chloride	lb.	2.45	—	2.50
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.75	—	.85
Beta naphthylamine, sublimed	lb.	2.65	—	....
Dichlor benzol	lb.	.15	—	.20
Diethylaniline	lb.	3.50	—	4.00
Dinitro benzol	lb.	.36	—	.38
Dinitrochlorbenzol	lb.	.39	—	.41
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.65	—	.75
Dinitrophenol	lb.	.49	—	.50
Dimethylaniline	lb.	.70	—	.73
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	3.00	—	3.25
Metaphenylenediamine	lb.	1.85	—	2.05
Monochlorbenzol	lb.	.16	—	.19
Naphthalene, flake	lb.	.09	—	....
Naphthalene, balls	lb.	.11	—	.12½
Naphtionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	1.00	—	1.10
Ortho-nitro-toluol	lb.	.75	—	.85
Para-amidophenol, base	lb.	4.50	—	....
Para-amidophenol, H. C. L	lb.	4.25	—	5.00
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.75	—	1.85
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.50	—	4.00
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.50	—	3.75
Phenol, U. S. P	lb.	.30	—	.40
Resorcin, technical	lb.	4.50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid U. S. P	lb.	.77	—	.85
Salol	lb.	1.50	—	2.00
Sulphanilic acid, crude	lb.	.31	—	.33
Toluidine	lb.	2.50	—	3.00
Toluidine-mixture	lb.	1.00	—	....

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	....
Corning, Ohio	bbl.	2.85	—	....
Somerset, Ky	bbl.	2.60	—	....
Wooster, Ohio	bbl.	2.68	—	....
Indiana	bbl.	2.28	—	....
Illinois	bbl.	2.42	—	....
Oklahoma and Kansas	bbl.	2.25	—	....
Caddo, La., light	bbl.	2.25	—	....
Corsicana, Tex., light	bbl.	2.25	—	....
California	bbl.	1.24	—	1.57
Gulf Coast	bbl.	1.35	—	....
Mexican	bbl.	1.90	—	....
Fuel Oil				
New York	gal.	.15	—	....
Philadelphia	gal.	.10½	—	....
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	.10½
Texas	bbl.	1.85	—	2.35
Los Angeles	bbl.	1.65	—	....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	....
Gas machine	gal.	.41½	—	....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	....
Chicago, motor	gal.	.22½	—	.23
Oklahoma, motor	gal.	.21½	—	....
San Francisco, motor	gal.	.20½	—	....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	....
Refined, 120 deg. m.pt	lb.	.13½	—	....
Refined, 128 deg. m.pt	lb.	.14	—	....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.45	—	.50
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.36	—	.38
Paraffine, 0.885 sp. gr	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	....

Naval Stores

Rosin A-E barrel	280 lb.	14.40	—	14.75
Rosin F-I	280 lb.	14.75	—	15.00
Rosin K-N	280 lb.	16.75	—	17.75
Rosin WG-W	280 lb.	17.85	—	18.25
Spirits of turpentine	gal.	.71	—	....
Wood turpentine, steam distilled	gal.	.62	—	.65
Wood turpentine, destructively distilled	gal.	.58	—	....
Pitch	bbl. 200 lb.	8.00	—	....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.80	—	....
Second run	gal.	.83	—	....
Third run	gal.	.88	—	....
Fourth run	gal.	.98	—	....

Vegetable Oils

Castor oil	lb.	.33	—	.34
China wood oil	lb.	.25	—	.28
Cocoanut oil	lb.	.16	—	.21
Corn oil	lb.	.18	—	....
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.81	—	1.86
Palm	lb.	.17½	—	.18½
Peanut oil, crude	lb.	.18	—	.22
Soya bean oil, Manchuria	lb.	.17	—	.18½

Glues

Extra white	lb.	.36	—	.45
Cabinet	lb.	.31	—	.40
Brown foot stock	lb.	.18	—	.22
Fish glue, 50-gal. barrels	gal.	1.00	—	1.80

Miscellaneous Materials

		Nominal		
Barytes, floated, white, foreign	ton			
Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	....
Casein	lb.	.17½	—	.30
Ceylon graphite	lb.	.07½	—	.25
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f.o.b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Japan wax	lb.	.26	—	.27
Mexican graphite	ton	60.00	—	75.00
Madagascar graphite	lb.	.10	—	.15
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Red lead, dry, carloads	100 lb.	.11½	—	.11½
Soapstone	ton	15.00	—	25.00
Stearic acid, 120 deg. m.pt	lb.	.13	—	.14
Stearic acid, 140 deg. m.pt	lb.	.18	—	.19
Talc, American, white	ton	20.00	—	40.00
White lead, dry	lb.	.09½	—	.10½

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	175.00	—	....
Chrome cement	net ton	75.00	—	....
Clay brick, first quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	50.00	—	60.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	240.00	—	....
Ferromanganese, English	ton	325.00	—	....
Spiegeleisen (16-18%)	ton	70.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton	....	—	....
Ferrosilicon, 50 per cent, contract	ton	153.00	—	160.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.40
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f.o.b. works	lb.	....	—	....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Chrome ore, 43 per cent and over, New York, per unit	ton	1.40	—	....
Coke	ton	6.00	—	7.00
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	1.50
Tungsten, Scheelite, per unit of WO_3	ton	25.50	—	....
Tungsten, Wolframite, per unit of WO_3	ton	23.00	—	....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	.17	—	....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	13.00	—	14.00
Hollow tile, 4x12x12	M	60.00	—	....
Hollow tile, 12x12x12	M	170.00	—	....
Lime	ton	16.50	—	....
Portland cement	bbl.	2.59	—	....
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Fir lumber	M	38.00	—	53.00
Hemlock	M	24.50	—	40.00
Tarred felt (14-lb. sq.)	ton	68.00	—	....
Roofing pitch	ton	27.00	—	....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	11.84	—	14.00
Red lead in oil	100 lb.	12.28	—	14.50
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	84.00	—	89.00
Black sheet iron	ton	96.00	—	104.00
Galvanized iron	ton	105.00	—	135.00
Tern plate, 8-lb. coating	ton	150.00	—	....
Tern plate, 15-lb. coating	ton	177.50	—	....
Tern plate, 25-lb. coating	ton	200.00	—	....
Tern plate, 40-lb. coating	ton	240.00	—	....
Tin plate, prime	ton	155.00	—	....
Tank plates	ton	65.00	—	65.00
Beams, channels, angles, T's, Z's	ton	60.00	—	70.00
Rivets	ton	88.00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51.00	—	....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steels, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	36.60	—	....
Bessemer steel	ton	47.50	—	....
No. 2 foundry	ton	37.90	—	....
Steel billets (4 x 4)	ton	47.50	—	....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	....
Asbestos, wired	lb.	1.30	—	....
Asbestos, graphited braid	lb.	1.21	—	....
Asbestos, wick	lb.	.75	—	....
Rubber, sheet	lb.	.66	—	....
Cup grease	lb.	.07	—	....
Transmission grease	lb.	.07	—	....
Axle grease	lb.	.04½	—	....
Gear grease	lb.	.04½	—	....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in.	ft.	.75	—	....
Hose, air, ¾ in.	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

ANNISTON—The Woodstock Iron & Steel Corporation will rebuild its sintering plant used for desulphurizing iron ores, recently destroyed by fire entailing a loss of $100,000.

Arizona

KINGMAN—The Catherine Mines will rebuild its mill at Pyramid, near here, and plans to renew operations on a larger scale.

MAYER—The Arizona Binghampton Copper Co. recently increased its capital stock to provide for extensions. Plans include the construction of a new addition to its flotation mill and the sinking of a new three-compartment shaft 1200 ft. It is understood that the company is planning for the erection of an aerial tram to the Humboldt smelter, about five miles.

WINKLEMAN—The Lavelle Gold Mining Co. will build a mill building, a 12 x 15 ft. dodge crusher, 50-ton Quenner dry crusher, amalgamation plates, four Wilfley tables and is in the market for crushers, plates, tables and accessories for second unit which will be built in July, 1919. Estimated cost, $60,000. A. Parker, 315 North 2nd St., Phoenix, superintendent.

California

CORONA—D. C. Crookshank, 322 East Holt St., will soon receive bids for the construction of a two-story, 80 x 88 ft. acid house for the Exchange By-Products Co., Corona. R. H. Orr, 1391 Van Nuys Bldg., Los Angeles, architect.

CORONA—The Exchange By-Products Co. has awarded the contract for the construction of a two-story, 80 x 88 ft. acid house, to the Oresmer Manufacturing Co., Riverside. Estimated cost, $30,000.

LOS ANGELES—The Western Pipe & Steel Co., North Broadway, has acquired a tract consisting of 130 lots in the Hay District, Vernon, near here, and will build extensions for the manufacture of riveted steel, iron and steel pipe, oil well castings, tanks, etc.

Colorado

CRIPPLE CREEK—The Lincoln Mines & Reduction Co. will build a new concentration plant at its manganese properties.

DURANGO—Bulkeley Wells and associates will build a new mill having a daily capacity of 200 tons in connection with the development of large alunite-potash deposits on Calico Peak.

PITKIN—The Pennsylvania Molybdenum Mines Co. will build a new mill at its Bon Ton mine.

Connecticut

NEW LONDON—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a laboratory building, to T. A. Cassidy, Fitchburg, Mass. Estimated cost, $17,800.

Delaware

NEW CASTLE—The American Manganese Steel Co. will build a one story, 60 x 60 ft. addition to its core oven works. Estimated cost, $18,000.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Department, has awarded the contract for the construction of a laboratory building here, to the Boyle-Robertson Construction Co., Evans Bldg. Noted Nov. 30.

Florida

KEY WEST—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a photo-laboratory here. Estimated cost, $7000. Noted Dec. 16.

OKEELANTA — The Okeelanta Stock Farms Packing & Canning Co., 212 New Tatum Bldg., Miami, will build a dehydrating and canning plant in connection with its hog farm here.

Georgia

GRIFFIN—The Georgia Cotton Mills will enlarge its bleachery and will install kier, one set of dry cans, mangle, switcher and calender.

Idaho

KELLOGG—The Mullan Milling Co. will install fine crushing and flotation machinery and equipment in the new 150-ton mill recently completed.

WALLACE—The Spokane Metals Recovery Co., operating at Nine Mile, near here, will rebuild its plant recently destroyed by fire, entailing a loss of over $22,000. Plans include the installation of a ball mine and other equipment.

Illinois

CHICAGO—John F. Jelke Co., 759 South Washtenaw Ave., will build an addition to its butterine factory.

CHICAGO—R. J. Kittredge & Co., 812 Sulphur St., has purchased a site on West 47th St., and Whipple Ave., and will build a large plant for the manufacture of labels and wrappers. The first unit is estimated to cost $200,000.

CHICAGO—Wilson & Co., 41st St. and Ashland Ave., has awarded the contract for the construction of a 3 story, 20 x 34 ft. fertilizer, dryer and storage building, to J. B. Mullen, 1728 South Michigan Ave. Estimated cost, $65,000. Noted Oct. 15.

MAYWOOD—The Sanitary District, 900 South Michigan Ave., Chicago, will build a one and two story treating plant, to include drying plant, pumping station, etc. Total estimated cost, $800,000. E. L. Barrett, 900 South Michigan Ave., Chicago, architect.

Indiana

HARTFORD CITY—The Ft. Wayne Corrugated Paper Co., Murray and Barr St., Ft. Wayne, will build a two story addition to its factory here. D. S. Griffith, owner.

Iowa

CLARINDA—The city has had plans prepared for the construction of a mechanical filtration plant to purify the water obtained from the Nodaway River.

KEOKUK—The Gas Tank Recharging Co. will build a plant here for the manufacture of calcium carbide. Estimated cost, $500,000.

Kentucky

MARION—John Summers and associates will install a jig mill on a mining tract here and is in the market for equipment for same.

PADUCAH—The Union Mining Co., recently incorporated with a capital of $25,000, will develop about 140 acres of fluorspar and lead properties in the Paducah Section. Plans include the installation of new lead mining and fluorspar machinery. B. F. Weatzel, Shawnee Parkway and Chestnut Sts, Louisville, president.

Maryland

BALTIMORE—The Baugh Chemical Co., foot Clinton St., has awarded the contract for rebuilding its nitrate ovens, to C. L. Stockhausen, Marine Bank Building. Estimated cost, $20,000.

ELKTON—The Scott Fertilizer Co. will rebuild its plant recently destroyed by fire entailing a loss of $250,000.

SPARROW'S POINT—The Bethlehem Steel Co. has awarded the contract for the construction of a one story, 73 x 1070 ft. steel plate mill, to Deverill, Spencer & Co., 514 Garrett Building, Baltimore. Estimated cost between $150,000 and $200,000.

Massachusetts

BOSTON—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of five buildings of the modified Austin No. 1 type, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, $40,000.

BOSTON—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build a galvanizing plant here. Estimated cost, $50,000. C. W. Parks, chief.

CAMBRIDGE—Lever Bros. Co., 176 Broadway, has awarded the contract for the construction of a 5-story, 75 x 170 ft. addition to its factory for the manufacture of soap and glycerine, to Stone & Webster, 147 Milk St., Boston. Estimated cost, $500,000.

Michigan

DETROIT—Frederick Stearns & Co., Jefferson Ave., will build an eight story, 100 x 110 ft. drug manufacturing plant. Albert Kahn, Marquette Building, architect, preparing plans.

DETROIT—The Michigan Smelting & Refining Co., 1685 Joseph Campau Ave., has had plans prepared for the construction of a two story, 50 x 63 ft. cupola house, on Clay and Joseph Campau Aves. Albert Kahn, Marquette Building, architect.

PETOSKEY—The Petoskey Portland Cement Co. will build a cement plant. J. C. Buckley, 38 South Dearborn St., Chicago, Ill., engineer.

Minnesota

COLUMBIA HEIGHTS—The city will receive bids about June for the construction of a sewerage system. J. W. Shaffer, New York Life Building, Minneapolis, engineer.

ST. PAUL—O. B. Dailey & Son, 460 Selby Ave., will build a factory for the manufacture of gasoline substitute.

Missouri

ST. LOUIS—The Christian Brothers College, 5270 Page Ave., will install a chemical laboratory in the three story college which it will build on Clayton and Skinker Roads. Estimated cost, $200,000. Henry P. Hess, 4811 Cote Brilliant Ave., engineer.

ST. LOUIS—The Goodyear Metallic Rubber Shoe Co., 500 Bittner St., has awarded the contract for the construction of a two-story, 62 x 65 ft. vulcanizing building, to the Unit Construction Co., Title Guarantee Building. Estimated cost, $20,000.

ST. LOUIS—The St. Louis Hide & Tallow Co., 412 Talcott Ave., will rebuild its hide and tallow factory recently destroyed by an explosion, entailing a loss of $15,000.

New Jersey

BOUND BROOK—A. A. Marlow & Sons will build a chemical plant for the manufacture of liquid sulphur and chemicals and are in the market for sheet lead, lead pipes, boilers, compressors, sulphur burners, storage tanks and cylinders.

GLOUCESTER—The United States Government will build a fumigation plant and laundry here. Estimated cost, $26,000.

New Mexico

FT. HANCOCK—A. Kraft, operating a copper mine near here, will build a new 100-ton gravity concentrating and flotation mill at his plant.

New York

BROOKLYN—John Bene & Sons, 641 Dean St., will build a three story, 100 x 100 ft. chemical factory on Carlton Ave. near Fulton St. W. H. Gompert, 171 Madison Ave., New York City, engineer.

BUFFALO—The Buffalo Slag Co., Ellicott Square, will build a one story, 70 x 100 ft. crusher plant. Estimated cost, $12,000.

BUFFALO—W. P. Whitney, architect, 38 South Dearborn St., is preparing plans for the construction of a clay products plant in the suburbs near here. Plans include a one story, 10 x 12 x 700 ft. conveyor house; one story, 57 x 200 ft. warehouse, two small storage buildings, etc. Total estimated cost, $100,000. Owner's name withheld.

NEW YORK—F. L. Dowling, president of Manhattan Borough, has awarded the contract for furnishing and delivering liquid chlorine, to the Electro Bleach & Gas Co., 13 East 41st St., $6120; furnishing and delivering sulphate of copper, to J. Grieg, 39 Cortlandt St., $2901. Noted Dec. 16.

NIAGARA FALLS—The Acheson Graphite Co., Buffalo Ave., has awarded the contract for the construction of an addition to its plant, to the John W. Cowper Co., Fidelity Building, Buffalo. Estimated cost, $15,000.

North Carolina

MONROE—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a radio building here. Estimated cost, $250,000. Noted Dec. 15.

Ohio

AKRON—The Akron Soap Co., Cuyahoga St., will build a two story, 40 x 50 ft. disposal plant. Estimated cost, $5,000.

CANTON—The Republic Rubber Corporation, Albert St., Youngstown, will enlarge its plant here, to double its present capacity.

CLEVELAND—The Cleveland Furnace Co., 1314 Rockefeller Building, will build a one story, 52 x 62 ft. laboratory building, at 315 Clark Ave. Estimated cost, $6000. F. A. Dearborn, c/o owner, architect.

CLEVELAND—The Grasselli Chemical Co., Guardian Building, will build a one story, 82 x 204 ft. chemical plant, at 2625 Independence Rd. Estimated cost, $25,000.

CLEVELAND—The Ohio Bronze Powder Co., 1120 East 152nd St., has awarded the contract for the construction of a two story, 56 x 70 ft. factory, to the McMillan Co., 1794 East 55th St. Estimated cost, $18,000.

CLEVELAND—The United States Copper Co., Guardian Building, has awarded the contract for the construction of a brass and copper tube mill, to the Hunkin Conkey Construction Co., Century Bldg. Estimated cost, $100,000. Noted Dec. 15.

PARMA—(Cleveland P. O.)—Swift & Co., 3240 West 65th St., has awarded the contract for the construction of a two story, 50 x 75 ft. fertilizer factory, to the William Moore Co., 1278 West 4th St., Cleveland. Estimated cost, $25,000. Noted Oct. 31.

TOLEDO—The Paragon Refining Co., 2935 Front St., will improve its plant. Estimated cost, $50,000. J. C. Smith, secretary.

TOLEDO—The S. S. Royster Guano Co., Second National Bank Building, will build a sulphuric acid plant adjoining its present plant. Estimated cost, $500,000.

TOLEDO—The Standard Steel Tube Co., Fitchland Ave. and Detroit & Michigan Central R. R., has purchased a 40 acre site on South Detroit Ave., and will build a factory. Estimated cost, $500,000.

YOUNGSTOWN—The Industrial Gas & Chemical Co., recently incorporated with a capital of $250,000, will build a plant for the manufacture of welding gases, chemicals and dyestuffs.

Oklahoma

BLACKWELL—The Bartlesville Zinc Co. will enlarge its plant here.

LAWTON—The city has awarded the contract for the construction of a filtration plant, to the Selden-Breck Construction Co., Fullerton Building, St. Louis, Mo. Estimated cost, $157,000.

OKLAHOMA—The American Castor Oil Co., 600 Colcord Building, will build a ten-ton plant and install machinery in same. Estimated cost, $50,000. H. C. Leete, manager.

TULSA—The United States Compression Inner Tube Co., Daniels Building, will build a plant for the manufacture of rubber inner tubes for automobiles. C. R. Porter, secretary-treasurer.

Oregon

BAKER—Harry M. Quinn and C. G. Flanagan, Seattle, will install a flotation plant to replace the old 60-ton concentrator in the Highland Mine near here.

SUMMER LAKE—Jason C. Moore has leased Summer Lake from the State Land Board and will build a commercial reduction soda plant, for the manufacture of soda ash and potash, produced from the deposits of the lake. When production begins, royalty will be paid to the State Land Board at the rate of $.25 per ton for soda ash and $.50 for potash. Estimated cost, $90,000. E. W. Lazell, Railway Exchange Building, Portland, chemical engineer.

Pennsylvania

MARCUS HOOK—The National Aniline & Chemical Co. has awarded the contract for the construction of a 106 x 109 ft. modified Austin No. 9 building to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, $32,000.

MT. HOLLY SPRINGS—The Mt. Holly Paper Co. has awarded the contract for the construction of a one story, 22 x 25 ft. addition to its paper factory, to H. A. Lackey, 520 North West St., Carlisle. Estimated cost, $5000.

PHILADELPHIA—The Kensington Hygeia Ice Co. has awarded the contract for the construction of a one story addition to the new cooling tower on Trenton Ave. and Huntingdon St., to the Cooling Tower Co., 15 John St., New York City, N. Y. Estimated cost, $5000.

PHILADELPHIA—The Samaritan Hospital, Ontario St., east of Broad St., will receive bids about June 1st, for the construction of a two-story, 25 x 81 ft. addition to its hospital, including a laboratory. Estimated cost, $12,000.

Rhode Island

PROVIDENCE—The Providence Steel & Iron Co., Kinsley Ave., has awarded the contract for the construction of a one-story fabricating plant, to Williams & Merchants, 87 Weybosset St. Estimated cost, $25,000.

South Dakota

HILL CITY—The American Tin & Tungsten Co. will remodel its plant near here and is in the market for a Telsmith gyratory crusher, Hardinge ball mill, Deister Plato slime table, Richards pulsator classifiers and electric furnace for smelting tin concentrates. Ralph S. Meyerin, superintendent.

Tennessee

BUTLER—The Elenor Manganese Co., recently incorporated with a capital of $15,000, will install the necessary equipment in the mine recently acquired from A. H. McQuenn to provide for an initial capacity of about 15 tons. R. B. Hayes, Masontown, Penn., president.

Texas

ABILENE—Charles Lindsey, 203 Fourth National Bank Building, Wichita, Kan., and others, have purchased a site here and will build an oil refinery. Estimated cost, $750,000.

COLLEGE STATION—The Board of Directors, Agricultural & Mechanical College of Texas, will receive bids until January 11 for the construction of a 65 x 130 ft. fireproof laboratory building for the Physics Department. Estimated cost, $60,000. W. Scott Dunne, Department of Architecture, architect.

FT. WORTH—Armour & Co., Union Stock Yards, Chicago, Ill., will build a six story, 220 x 300 ft. curing plant, having a 5,000,000 lb. capacity, in connection with the improvements which it plans to make to its packing plant. Total estimated cost, $500,000.

FT. WORTH—The Baltic Refining Co. has awarded the contract for the construction of a concrete and steel oil refinery, having a daily capacity of 500 barrels, to the Bryce Building Co., 909 Throckmorton Building. Equipment for refining petroleum into all finished products, including gasoline, kerosene, lubricating oils and wax will be installed in same. Estimated cost, $750,000.

FT. WORTH—The El Dorado Refining Co. will build a 5000 barrel refinery here. Estimated cost, $1,000,000.

FT. WORTH—The Evans Thwing Co. will build a refinery, having a capacity of 3500 barrels, on the site of the Tarrant County poor farm. Estimated cost, $600,000.

FT. WORTH—The Army and Navy Departments, Washington, D. C., will build a plant adjoining the Government experimental plant here for the manufacture of balloon gas. Estimated cost, $5,000,000.

FT. WORTH—The Sterling Oil & Refining Co., 511 Beacon Building, Wichita, Kan., will build an oil refinery here, to have an initial capacity of 5000 barrels. W. McGinley, president.

LA PORTE—Palmer Hughes, 912 Oxford St., and associates, have purchased a site near here and will build an oil refinery having a daily capacity of 600 barrels.

Virginia

LYNCHBURG—The Sanitax Dry Cleaning Co., Main and Chestnut St., has awarded the contract for the construction of a one story, 50 x 69 ft. dry cleaning plant, to W. B. Snead & Co., 1321 Main St. Estimated cost, $15,000.

NORFOLK—The Norfolk Glass Manufacturing Co., 564 Church St., will build a plant near Berkley St. for the manufacture of glass specialties. Estimated cost, $200,000.

NORFOLK—The Virginia Fruit Juice Co., 4-12 Washington Ave., has awarded the contract for the construction of a two story, 44 x 65 ft. vinegar plant, to J. H. Pierce, Law Building.

PORTSMOUTH—The Southern Brass Works, National Bank of Portsmouth Building, has awarded the contract for the construction of a one story, 40 x 67 ft. extension to its plant, to John W. Hoffler, 504 5th St.

Washington

LOON LAKE—The Loon Lake Copper Co. will build a concentrating mill, to have a daily capacity of 100 tons. Estimated cost, $45,000. C. J. Stone, manager.

VALLEY—The Admiral Mining Co., Rookery Building, Spokane, has been authorized to issue $75,000 bonds, $50,000 of which will be used for concentrator to be installed here, if development work justifies same. J. Richard Brown, manager.

Wisconsin

JEFFERSON—The Board of Commissioners of Jefferson County will install a private water system and septic tanks in the two and three story, 100 x 150 ft. sanitarium which it will build. Estimated cost, $75,000. O. C. Uehling, First National Bank Building, Milwaukee, architect.

MILWAUKEE—The Milwaukee Gas Light Co., Milwaukee and Menominee St. will alter its gas plant. Estimated cost, $65,000.

MILWAUKEE—The Milwaukee Paper Box Co., 400 Florida St., will build a five story, 120 x 144 ft. manufacturing building and garage, on Pierce and Muskego Sts. Estimated cost, $225,000. Schnetzky & Son, 105 Wells St., architect.

RACINE—The Osborne Casting Co., Layard Ave., will build an addition to its core room, foundry and auxiliary building. Estimated cost, $20,000. C. G. Holmes, general superintendent.

Nova Scotia

HALIFAX—The Canada Metal Co., 37 Fraser Ave., Toronto, will build a plant here. Estimated cost, $50,000. W. G. Harris, president.

Ontario

BOSTON CREEK—The Miller Independence Mining Co. has increased its capital stock and will build an addition to its existing plant, and is in the market for crushing and grinding machinery and flotation mill and electrical equipment. George Miller, superintendent.

Quebec

CLARK CITY—The Gulf Pulp & Paper Co. will build a paper mill. Estimated cost, $10,000. T. Clark, superintendent.

Mexico

CUSIHUIRIACHIC—The Compania Minera del Mirasol will build a 200-ton concentrating mill. C. B. Clyne, Mills Bldg., El Paso, Texas, is preparing plans.

Manufacturers' Catalogs

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, calls attention to a 72-page catalog, No. 244, on the Jeffrey bucket elevators in standard sizes. Forty pages are devoted to details of elevators selected out of numerous styles used in the handling of a wide range of materials in practically every industry of the country and known as Standard Elevators. A page is given to each Standard Elevator, which is illustrated, both in perspective and in line drawing, giving dimensions. There is also an illustration showing the chain and bucket used in that type of elevator, and at the bottom of each sheet is given a full list of all specifications applying to that particular elevator. This attractive catalog is ready for distribution to the trade.

THE INDEPENDENT FILTER PRESS CO., INC., Brooklyn, N. Y., has issued a catalog on the Indefico filter press, and calls attention to patent No. 1,282,414 on an improved field plate, which is illustrated and described.

THE AMERICAN ZINC, LEAD & SMELTING CO., St. Louis, Mo., has just received from the press a 36-page booklet dealing with Azo zinc oxides, which will be sent upon request to any member of the trade.